20-65

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HESS GEOTECHNICAL CORP.
EL CENTRO, CALIFORNIA 92244

MEMO

DATED: January 27, 1984

The attached sheet describes the tile water recording program for 1982, 1983 and 1984. The map is a reduced document from the larger color-coded map, on file, at our office.

cc.: Donald A. Twogood (5) 1 Shreves 1

Reginald Knox (5) Wilson 3

Total Miles of Drain Tile Installed as of November 1983 = 28,941.48 Miles

Total Footage of Drain Tile Installed as of November 1983 = 152,811,014 Feet

SUMP DATA (TOTAL)

Salton Sea Sumps - - - - - - - - - 30

Other Sumps - - - - - - - - - - - - - 476

TOTAL - - - - - - - - - - - - 506

SUMPS (IN 1983-84 SAMPLING/RECORDING PROGRAM)

Salton Sea Sumps - - - - - - - - - 13

Other Sumps - - - - - - - - - - - - - 222

TOTAL - - - - - - - - - - - - 235

TILE OUTLETS

Total in Program (1983-84) - - - 45

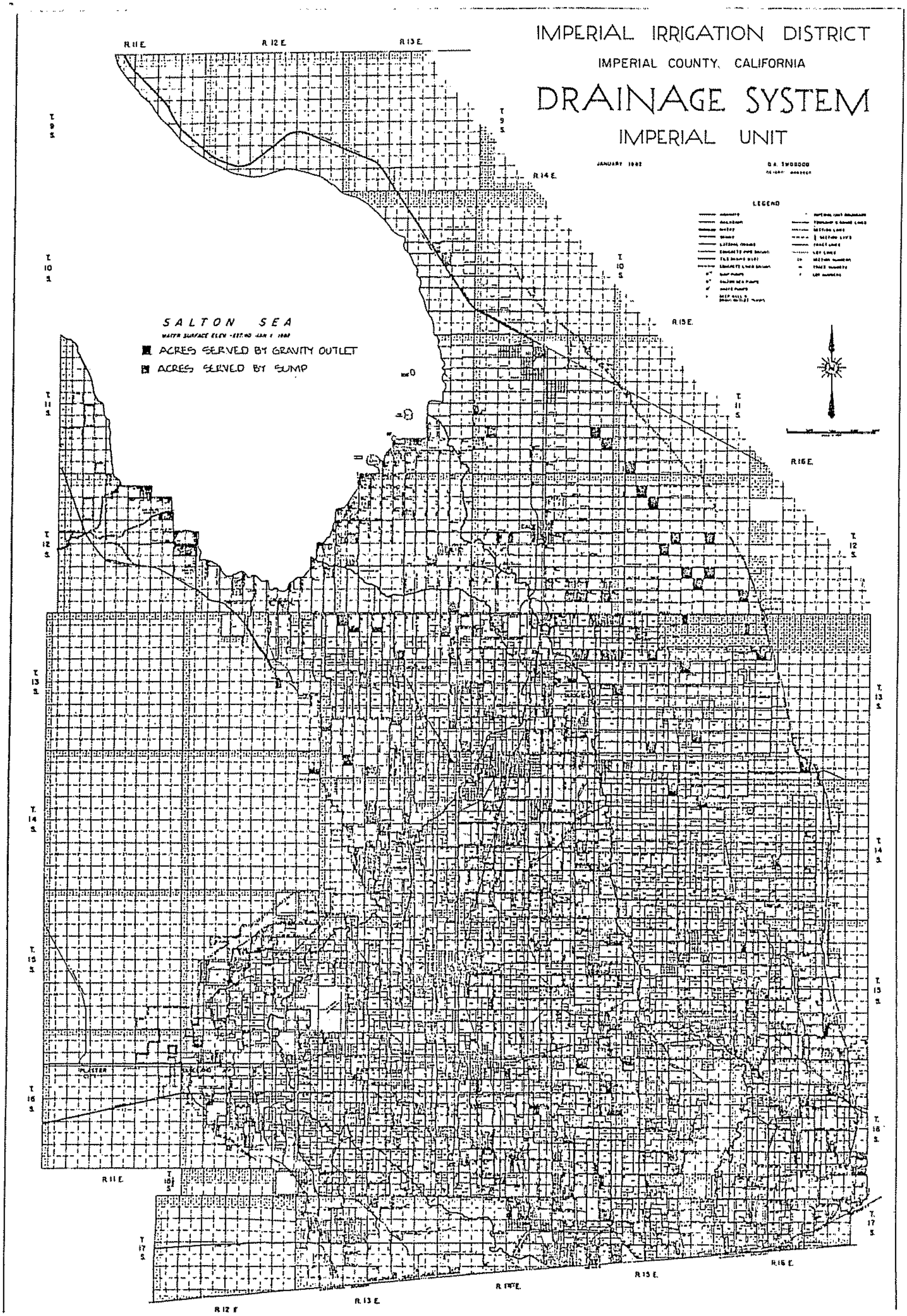
ACRES SERVED IN 1983-84 PROGRAM

Drain Tile Outlets - - - - - - - - 5,305 AC.

Sumps - - - - - - - - - - - - - - - 44,249 AC.

TOTAL - - - - - - - - - - 49,554 AC. % of Total = 10.77*

Total Irrigated Acreage Within IID Service Area (Est.) *460,000


IMPERIAL IRRIGATION DISTRICT
IMPERIAL COUNTY, CALIFORNIA
DRAINAGE SYSTEM
IMPERIAL UNIT
LEGEND
SALTON SEA
ACRES SERVED BY GRAVITY OUTLET
ACRES SERVED BY SUMP
R.11 E.
R.12 E.
R.13 E.
R.14 E.
R.15 E.
R.16 E.
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
T. 14 S.
T. 15 S.
T. 16 S.
T. 17 S.
PLASTER

20-66

E

HESS GEOTECHNICAL CORP.
EL CENTRO, CALIFORNIA 92244

MEMO

DATED: January 26, 1984

The attached Salton Sea water budget sheets (1951 through 1964) should be placed in the binder previously submitted with the 1965 through 1982 data.

You will note that in some instances, a negative figure "pops up" in the "other surface + groundwater input" column. Of course, this figure is further reflected in the cumulative column data.

At this time we are not certain whether the negative values are generated in the input or output data; however, in making a preliminary analysis of the data, we find that the error decreases with time, which indicates increased precision in measurement. On the other hand, some of this error may be due to variations between pan evaporation and actual sea water calculated evaporation. We will continue to look into this matter as time permits.

cc.: Donald A. Twogood ~~(5)~~ 1 Shreves 1

Reginald Knox (5) Wilson 3

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SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR : 1951

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DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
JAN 1	-239.60	198940	4396000	1785	1785	70000	70000	3.67	41981	41981	0.12	1989	1989.4	95813	95813	3382	3382	99195	99195	0	0	99195	99195	10797	1079
FEB 1	-239.25	200725	4466000	1020	2805	40000	110000	4.90	56554	98536	0.03	502	2491	87918	183731	3444	6826	91362	190557	0	0	91362	190557	4690	1548
MAR 1	-239.05	201745	4506000	1380	4185	61250	171250	7.07	82014	180550	0.00	0	2491	106212	289943	3016	9842	109228	299785	0	0	109228	299785	34036	4952
APR 1	-238.75	203125	4567250	675	4860	30750	202000	8.78	102548	283098	0.03	508	2999	103441	393384	6445	16287	109886	409671	0	0	109886	409671	22904	7242
MAY 1	-238.60	203800	4598000	-675	4185	-30750	171250	11.53	135114	418212	0.00	0	2999	94289	487673	2012	18299	96301	505972	0	0	96301	505972	8063	8049
JUN 1	-238.75	203125	4567250	225	4410	10250	181500	13.39	156391	574603	0.00	0	2999	95470	583143	1183	19482	96653	602625	0	0	96653	602625	69988	15047
JUL 1	-238.70	203350	4577500	-675	3735	-30750	150750	13.28	155278	729881	0.01	169	3168	96641	679784	1268	20750	97909	700534	0	0	97909	700534	26450	17692
AUG 1	-238.85	202675	4546750	0	3735	0	150750	13.04	151966	881847	1.27	21450	24618	91896	771680	1262	22012	93158	793692	0	0	93158	793692	37358	21428
SEP 1	-238.85	202675	4546750	0	3735	0	150750	9.08	105817	987663	0.00	0	24618	87172	858852	4422	26434	91594	885286	0	0	91594	885286	14223	22850
OCT 1	-238.85	202675	4546750	0	3735	0	150750	8.31	96843	1084507	0.00	0	24618	115554	974406	4589	31023	120143	1005429	0	0	120143	1005429	-23300	20520
NOV 1	-238.85	202675	4546750	1350	5085	61500	212250	4.89	56987	1141494	0.17	2871	27489	104359	1078765	3538	34561	107897	1113326	0	0	107897	1113326	7719	21292
DEC 1	-238.55	204025	4608250	1125	6210	51250	263500	4.32	50680	1192173	0.19	3230	30720	90642	1169407	2332	36893	92974	1206300	0	108000	92974	1314300	5725	21865
JAN 1	-238.30	205150	4659500								0.00										108000	0	108000	0	21865

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

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HESS GEOTECHNICAL CORP.

LTON.1972

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR: 1952

0

L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
	JAN 1	-238.30	205150	4659500																						
9					2475	2475	114000	114000	3.39	39989	39989	1.14	19489	19489.25	91391	91391	2610	2610	94001	94001	0	0	94001	94001	40499	4049
	FEB 1	-237.75	207625	4773500																						
7					1350	3825	63000	177000	4.23	50500	90488	0.06	1038	20527	98573	189964	1930	4540	100503	194504	0	0	100503	194504	11958	5245
	MAR 1	-237.45	208975	4836500																						
2					900	4725	42000	219000	7.13	85675	176163	0.08	1393	21921	107532	297496	3234	7774	110766	305270	0	0	110766	305270	15515	6797
	APR 1	-237.25	209875	4878500																						
9					1125	5850	52500	271500	7.67	92560	268723	0.02	350	22270	108952	406448	2912	10686	111864	417134	0	0	111864	417134	32846	10081
	MAY 1	-237.00	211000	4931000																						
6					200	6050	10650	282150	11.86	143891	412615	0.00	0	22270	106287	512735	2687	13373	108974	526108	0	0	108974	526108	45567	14638
	JUN 1	-236.95	211200	4941650																						
2					-1100	4950	-52650	229500	13.31	161637	574251	0.00	0	22270	100739	613474	2612	15985	103351	629459	0	0	103351	629459	5636	15202
	JUL 1	-237.20	210100	4889000																						
0					-225	4725	-10500	219000	12.65	152821	727073	0.00	0	22270	106694	720168	3109	19094	109803	739262	0	0	109803	739262	32518	18454
	AUG 1	-237.25	209875	4878500																						
5					-675	4050	-31500	187500	12.51	150968	878041	0.00	0	22270	106425	826593	3869	22963	110294	849556	0	0	110294	849556	9174	19371
	SEP 1	-237.40	209200	4847000																						
9					-225	3825	-10500	177000	11.06	133041	1011082	0.00	0	22270	112646	939239	3290	26253	115936	965492	0	0	115936	965492	6605	20031
	OCT 1	-237.45	208975	4836500																						
3					675	4500	31500	208500	6.74	80988	1092070	0.00	0	22270	132089	1071328	3256	29509	135345	1100837	0	0	135345	1100837	-22857	17746
	NOV 1	-237.30	209650	4868000																						
1					675	5175	31500	240000	4.27	51474	1143544	0.63	11007	33277	97354	1168682	4045	33554	101399	1202236	0	0	101399	1202236	-29431	14803
	DEC 1	-237.15	210325	4899500																						
5					2275	7450	116700	356700	2.26	27332	1170876	0.52	9114	42391	91891	1260573	3613	37167	95504	1297740	0	86000	95504	1383740	39414	18744
	JAN 1	-236.60	212600	5016200																						
5												0.00										86000	0	86000	0	18744

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR: 1953

0

L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
-	JAN 1	-236.60	212600	5016200																						
2					600	600	31950	31950	3.34	40830	40830	0.00	0	0	100493	100493	1875	1875	102368	102368	2914	2914	105282	105282	-32502	-3250
	FEB 1	-236.45	213200	5048150																						
6					1000	1600	53250	85200	4.99	61172	102002	0.02	355	355	104197	204690	1742	3617	105939	208307	4522	7436	110461	215743	3606	-2889
	MAR 1	-236.20	214200	5101400																						
6					1000	2600	53500	138700	6.80	83752	185754	0.00	0	355	117710	322400	2663	6280	120373	328680	5439	12875	125812	341555	11440	-1745
	APR 1	-235.95	215200	5154900																						
7					200	2800	10900	149600	9.99	123616	309371	0.00	0	355	111961	434361	4246	10526	116207	444887	5370	18245	121577	463132	12939	-451
	MAY 1	-235.90	215400	5165800																						
3					-400	2400	-21800	127800	13.81	171044	480414	0.00	0	355	123861	558222	3217	13743	127078	571965	5746	23991	132824	595956	16420	1190
	JUN 1	-236.00	215000	5144000																						
9					200	2600	10900	138700	12.92	159723	640138	0.00	0	355	110440	668662	2188	15931	112628	684593	4880	28871	117508	713464	53115	6501
	JUL 1	-235.95	215200	5154900																						
5					-200	2400	-10900	127800	12.23	151334	791472	0.00	0	355	112457	781119	2133	18064	114590	799183	3858	32729	118448	831912	21986	8700
	AUG 1	-236.00	215000	5144000																						
0					-1400	1000	-74550	53250	12.51	154655	946127	0.00	0	355	111797	892916	1352	19416	113149	912332	5721	38450	118870	950782	-38765	4824
	SEP 1	-236.35	213600	5069450																						
5					400	1400	21300	74550	9.40	115451	1061578	0.00	0	355	111768	1004684	3128	22544	114896	1027228	6609	45059	121505	1072287	15246	6348
	OCT 1	-236.25	214000	5090750																						
6					400	1800	21300	95850	7.80	95979	1157557	0.00	0	355	131128	1135812	3770	26314	134898	1162126	8620	53679	143518	1215805	-26239	3724
	NOV 1	-236.15	214400	5112050																						
4					1000	2800	53750	149600	5.22	64352	1221909	0.04	715	1070	109753	1245565	3507	29821	113260	1275386	5430	59109	118690	1334495	-1303	3594
	DEC 1	-235.90	215400	5165800																						
6					600	3400	32700	182300	4.53	56106	1278015	0.00	0	1070	100433	1345998	2603	32424	103036	1378422	3498	62607	106534	1441029	-17728	1821
	JAN 1	-235.75	216000	5198500																						
6												0.00										62607	0	62607	0	1821

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

LTON.1972

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1954

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT\ A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
-	JAN 1	-235.75	216000	5198500																						
7					1800	1800	98100	98100	2.88	35770	35770	0.45	8100	8100	100329	100329	2977	2977	103306	103306	3617	3617	106923	106923	18847	1884
	FEB 1	-235.30	217800	5296600																						
7					1200	3000	65400	163500	5.04	63118	98888	0.00	0	8100	93651	193980	1980	4957	95631	198937	2287	5904	97918	204841	30600	4944
	MAR 1	-235.00	219000	5362000																						
8					750	3750	55250	218750	7.27	91547	190436	0.40	7300	15400	120844	314824	3196	8153	124040	322977	7397	13301	131437	336278	8060	5750
	APR 1	-234.75	219750	5417250																						
6					-150	3600	42950	261700	8.65	109298	299734	0.00	0	15400	113835	428659	1794	9947	115629	438606	2761	16062	118390	454668	33858	9136
	MAY 1	-234.80	219600	5460200																						
7					0	3600	-54000	207700	10.08	127280	427014	0.00	0	15400	121041	549700	3057	13004	124098	562704	6061	22123	130159	584827	-56879	3448
	JUN 1	-234.80	219600	5406200																						
2					150	3750	11050	218750	11.42	144200	571214	0.00	0	15400	109678	659378	1425	14429	111103	673807	7812	29935	118915	703742	36335	7082
	JUL 1	-234.75	219750	5417250																						
2					-150	3600	-11050	207700	11.31	142909	714123	0.20	3662	19062	107312	766690	1147	15576	108459	782266	7428	37363	115887	819629	12309	8313
	AUG 1	-234.80	219600	5406200																						
7					-1400	2200	-87800	119900	11.40	143948	858071	0.10	1830	20892	104328	871018	1870	17446	106198	888464	8594	45957	114792	934421	-60474	2265
	SEP 1	-235.20	218200	5318400																						
2					600	2800	32700	152600	8.85	111037	969107	0.09	1637	22529	110339	981357	2601	20047	112940	1001404	11115	57072	124055	1058476	18045	4070
	OCT 1	-235.05	218800	5351100																						
7					0	2800	0	152600	7.23	90961	1060068	0.00	0	22529	113778	1095135	4127	24174	117905	1119309	5351	62423	123256	1181732	-32295	840
	NOV 1	-235.05	218800	5351100																						
9					500	3300	33000	185600	4.50	56615	1116683	0.05	912	23441	93060	1188195	3260	27434	96320	1215629	5699	68122	102019	1283751	-13316	-490
	DEC 1	-234.90	219300	5384100																						
9					450	3750	33150	218750	4.76	60022	1176705	0.00	0	23441	85015	1273210	3502	30936	88517	1304146	4345	72467	92862	1376613	310	-459
	JAN 1	-234.75	219750	5417250																						
9												0.00										72467	0	72467	0	-459

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

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HESS GEOTECHNICAL CORP.

LTON.1972

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1955

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
	JAN 1	-234.75	219750	5417250																						
7					750	750	55250	55250	2.64	33358	33358	0.80	14650	14650.00	55824	55824	6274	6274	62098	62098	7713	7713	69811	69811	4147	414
	FEB 1	-234.50	220500	5472500																						
7					600	1350	44200	99450	4.52	57308	90666	0.00	0	14650	76200	132024	3659	9933	79859	141957	5499	13212	85358	155169	16150	2029
	MAR 1	-234.30	221100	5516700																						
2					750	2100	55250	154700	7.49	95222	185888	0.00	0	14650	95839	227863	3476	13409	99315	241272	4362	17574	103677	258846	46795	6709
	APR 1	-234.05	221850	5571950																						
6					150	2250	11050	165750	10.52	134197	320085	0.00	0	14650	97217	325080	1529	14938	98746	340018	4047	21621	102793	361639	42454	10954
	MAY 1	-234.00	222000	5583000																						
7					-450	1800	-33150	132600	13.08	166966	487052	0.00	0	14650	101487	426567	2342	17280	103829	443847	5267	26888	109096	470735	24720	13426
	JUN 1	-234.15	221550	5549850																						
5					-450	1350	-33150	99450	13.14	167392	654444	0.00	0	14650	85197	511764	2366	19646	87563	531410	8921	35809	96484	567219	37758	17202
	JUL 1	-234.30	221100	5516700																						
3					-450	900	-33150	66300	11.84	150525	804968	0.02	368	15018	92827	604591	2301	21947	95128	626538	8650	44459	103778	670997	13228	18525
	AUG 1	-234.45	220650	5483550																						
7					0	900	0	66300	10.74	136262	941231	0.06	1103	16122	103390	707981	4548	26495	107938	734476	10037	54496	117975	788972	17184	20243
	SEP 1	-234.45	220650	5483550																						
4					-900	0	-66300	0	10.36	131441	1072672	0.00	0	16122	92461	800442	3446	29941	95907	830383	8307	62803	104214	893186	-39073	16336
	OCT 1	-234.75	219750	5417250																						
5					300	300	22100	22100	7.56	95525	1168197	0.00	0	16122	103120	903562	5413	35354	108533	938916	10042	72845	118575	1011761	-950	16241
	NOV 1	-234.65	220050	5439350																						
1					150	450	11050	33150	6.40	80978	1249176	0.00	0	16122	90916	994478	6891	42245	97807	1036723	6355	79200	104162	1115923	-12134	15028
	DEC 1	-234.60	220200	5450400																						
8					750	1200	55250	88400	3.76	47607	1296783	0.05	917	17039	75331	1069809	6655	48900	81986	1118709	6167	85367	88153	1204076	13787	16406
	JAN 1	-234.35	220950	5505650																						
8												0.00										85367	0	85367	0	16406

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

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LTON.1972

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1956

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM OTH INP A.F.
-	JAN 1	-234.35	220950	5550650																						
2					600	600	-800	-800	3.57	45356	45356	0.01	184	184.1250	76546	76546	7039	7039	83585	83585	3918	3918	87503	87503	-43132	-431
	FEB 1	-234.15	221550	5549850																						
9					450	1050	33150	32350	5.37	68409	113765	0.01	185	369	75633	152179	5908	12947	81541	165126	4831	8749	86372	173875	15002	-281
	MAR 1	-234.00	222000	5583000																						
3					600	1650	44800	77150	7.98	101865	215629	0.00	0	369	90971	243150	6289	19236	97260	262386	7363	16112	104623	278498	42042	1391
	APR 1	-233.80	222600	5627800																						
3					300	1950	22400	99550	10.00	127995	343624	0.07	1298	1667	106991	350141	6736	25972	113727	376113	8729	24841	122456	400954	26641	405
	MAY 1	-233.70	222900	5650200																						
5					-300	1650	-22400	77150	12.28	157390	501014	0.00	0	1667	89114	439255	6507	32479	95621	471734	7957	32798	103578	504532	31412	719
	JUN 1	-233.80	222600	5627800																						
9					-450	1200	-33600	43550	12.15	155514	656528	0.00	0	1667	78864	518119	5794	38273	84658	556392	10022	42820	94680	599212	27234	991
	JUL 1	-233.95	222150	5594200																						
8					-300	900	-22250	21300	11.92	152262	808790	0.00	0	1667	104022	622141	6627	44900	110649	667041	6863	49683	117512	716724	12500	1116
	AUG 1	-234.05	221850	5571950																						
1					-1200	-300	-88400	-67100	12.44	158689	967479	0.00	0	1667	101199	723340	6271	51171	107470	774511	5207	54890	112677	829401	-42388	6931
	SEP 1	-234.45	220650	5483550																						
1					-300	-600	-22100	-89200	10.49	133091	1100569	0.00	0	1667	93227	816567	5798	56969	99025	873536	4445	59335	103470	932871	7521	768
	OCT 1	-234.55	220350	5461450																						
8					-600	-1200	-44200	-133400	8.63	109343	1209913	0.03	551	2218	106384	922951	6496	63465	112880	986416	4515	63850	117395	1050266	-52803	240
	NOV 1	-234.75	219750	5417250																						
4					300	-900	22100	-111300	5.34	67474	1277387	0.00	0	2218	88312	1011263	7633	71098	95945	1082361	3464	67314	99409	1149675	-9835	1419
	DEC 1	-234.65	220050	5439350																						
6					450	-450	33150	-78150	4.62	58456	1335843	0.00	0	2218	80541	1091804	7076	78174	87617	1169978	3287	70601	90904	1240579	702	1489
	JAN 1	-234.50	220500	5472500																						
6												0.00										70601	0	70601	0	1489

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

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SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1957

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM OTH INP A.
	JAN 1	-234.50	220500	5472500																						
9					900	900	66300	66300	2.91	36895	36895	0.57	10474	10473.75	70325	70325	8824	8824	79149	79149	3543	3543	82692	82692	10029	100
	FEB 1	-234.20	221400	5538800																						
1					900	1800	66600	132900	3.30	42011	78906	0.03	554	11027	68663	138988	5928	14752	74591	153740	3085	6628	77676	160368	30381	404
	MAR 1	-233.90	222300	5605400																						
8					300	2100	22400	155300	7.13	91137	170043	0.00	0	11027	88839	227827	5393	20145	94232	247972	3778	10406	98010	258378	15527	559
	APR 1	-233.80	222600	5627800																						
9					0	2100	0	155300	10.06	128763	298806	0.00	0	11027	103071	330898	5413	25558	108484	356456	3678	14084	112162	370540	16601	725
	MAY 1	-233.80	222600	5627800																						
8					-450	1650	-33600	121700	11.85	151674	450480	0.00	0	11027	93734	424632	5662	31220	99396	455852	4639	18723	104035	474575	14039	865
	JUN 1	-233.95	222150	5594200																						
2					-600	1050	-44350	77350	13.41	171294	621775	0.00	0	11027	85694	510326	4340	35560	90034	545886	6136	24859	96170	570745	30774	1173
	JUL 1	-234.15	221550	5549850																						
9					-750	300	-55250	22100	11.28	143697	765472	0.00	0	11027	84765	595091	3918	39478	88683	634569	5358	30217	94041	664786	-5594	1117
	AUG 1	-234.40	220800	5494600																						
9					-600	-300	-44200	-22100	11.37	144354	909825	0.30	5520	16547	84182	679273	6520	45998	90702	725271	4931	35148	95633	760419	-999	1107
	SEP 1	-234.60	220200	5450400																						
6					-450	-750	-33150	-55250	10.21	129274	1039099	0.00	0	16547	87136	766409	6513	52511	93649	818920	5448	40596	99097	859516	-2973	1077
	OCT 1	-234.75	219750	5417250																						
6					450	-300	33150	-22100	6.78	85670	1124769	0.87	15932	32479	104594	871003	6718	59229	111312	930232	5086	45682	116398	975914	-13510	942
	NOV 1	-234.60	220200	5450400																						
3					-300	-600	-22100	-44200	4.76	60269	1185038	0.00	0	32479	70873	941876	7041	66270	77914	1008146	4228	49910	82142	1058056	-43973	503
	DEC 1	-234.70	219900	5428300																						
8					750	150	55250	11050	2.61	33001	1218039	0.06	1100	33579	69503	1011379	6337	72607	75840	1083986	3457	53367	79297	1137353	7855	581
	JAN 1	-234.45	220650	5483550																						
8												0.00										53367	0	53367	0	581

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HESS GEOTECHNICAL CORP.

LTON.1972

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1958

L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
-	JAN 1	-234.45	220650	5483550																						
8					450	450	33150	33150	3.55	45040	45040	0.03	552	551.625	68267	68267	5813	5813	74080	74080	3451	3451	77531	77531	108	10
	FEB 1	-234.30	221100	5516700																						
4					900	1350	66300	99450	3.27	41572	86613	1.38	25427	25978	56461	124728	6771	12584	63232	137312	5117	8568	68349	145880	14097	1420
	MAR 1	-234.00	222000	5583000																						
7					750	2100	56000	155450	6.19	79015	165628	0.47	8695	34673	86192	210920	7940	20524	94132	231444	4656	13224	98788	244668	27532	4173
	APR 1	-233.75	222750	5639000																						
2					450	2550	33600	189050	9.34	119628	285256	0.26	4826	39499	97682	308602	8852	29376	106534	337978	5592	18816	112126	356794	36276	7801
	MAY 1	-233.60	223200	5672600																						
6					-450	2100	-33600	155450	12.07	154906	440162	0.02	372	39871	92850	401452	7663	37039	100513	438491	6338	25154	106851	463645	14083	9209
	JUN 1	-233.75	222750	5639000																						
6					-600	1500	-44800	110650	13.04	167018	607180	0.00	0	39871	81094	482546	8644	45683	89738	528229	5390	30544	95128	558773	27090	11918
	JUL 1	-233.95	222150	5594200																						
8					-1050	450	-77500	33150	13.70	174999	782179	0.00	0	39871	83177	565723	8060	53743	91237	619466	5539	36083	96776	655549	723	11990
	AUG 1	-234.30	221100	5516700																						
5					-300	150	-22100	11050	11.04	140354	922533	0.02	368	40240	81478	647201	11162	64905	92640	712106	3869	39952	96509	752058	21377	14128
	SEP 1	-234.40	220800	5494600																						
3					-900	-750	-66300	-55250	10.73	136228	1058761	0.00	0	40240	83142	730343	10666	75571	93808	805914	4892	44844	98700	850758	-28772	11251
	OCT 1	-234.70	219900	5428300																						
1					150	-600	11050	-44200	6.95	87878	1146639	0.02	366	40606	100334	830677	11740	87311	112074	917988	4089	48933	116163	966921	-17602	9491
	NOV 1	-234.65	220050	5439350																						
0					0	-600	0	-44200	4.77	60354	1206993	0.00	0	40606	80381	911058	9051	96362	89432	1007420	3703	52636	93135	1060056	-32781	6213
	DEC 1	-234.65	220050	5439350																						
9					150	-450	11050	-33150	2.25	28469	1235462	0.00	0	40606	62987	974045	9612	105974	72599	1080019	3721	56357	76320	1136376	-36801	2532
	JAN 1	-234.60	220200	5450400																						
9												0.00										56357	0	56357	0	2532

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HESS GEOTECHNICAL CORP.

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1959

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CUM' OTHE INPU A.F
-	JAN 1	-234.60	220200	5450400																					
8					900	900	66300	66300	3.71	46974	46974	0.09	1652	1651.5	65476	65476	10423	10423	75899	75899	4266	4266	80165	80165	31458	3145
	FEB 1	-234.30	221100	5516700																					
2					750	1650	55250	121550	3.91	49709	96683	0.20	3685	5336	65821	131297	10205	20628	76026	151925	3923	8189	79949	160114	21325	5278
	MAR 1	-234.05	221850	5571950																					
4					450	2100	33450	155000	7.53	96056	192738	0.00	0	5336	91019	222316	9963	30591	100982	252907	4812	13001	105794	265908	23712	7649
	APR 1	-233.90	222300	5605400																					
0					450	2550	33600	188600	9.43	120537	313275	0.00	0	5336	101235	323551	10275	40866	111510	364417	5171	18172	116681	382589	37456	11395
	MAY 1	-233.75	222750	5639000																					
9					-450	2100	-33600	155000	11.88	152161	465436	0.00	0	5336	91602	415153	9498	50364	101100	465517	5591	23763	106691	489280	11870	12581
	JUN 1	-233.90	222300	5605400																					
6					-600	1500	-44500	110500	13.04	166681	632116	0.00	0	5336	82721	497874	8054	58418	90775	556292	5269	29032	96044	585324	26137	15195
	JUL 1	-234.10	221700	5560900																					
3					-300	1200	-22100	88400	12.95	165083	797200	0.00	0	5336	87355	585229	7553	65971	94908	651200	5368	34400	100276	685600	42707	19466
	AUG 1	-234.20	221400	5538800																					
3					-750	450	-55250	33150	12.14	154548	951748	0.00	0	5336	86626	671855	10964	76935	97590	748790	5198	39598	102788	788388	-3490	19117
	SEP 1	-234.45	220650	5483550																					
2					-1050	-600	-77350	-44200	10.44	132456	1084204	0.20	3677	9014	93286	765141	11764	88699	105050	853840	4660	44258	109710	898098	-58281	13289
	OCT 1	-234.80	219600	5406200																					
4					600	0	44200	0	7.42	93692	1177896	0.09	1647	10661	111395	876536	11706	100405	123101	976941	3942	48200	127043	1025141	9202	14209
	NOV 1	-234.60	220200	5450400																					
2					300	300	22100	22100	4.63	58623	1236519	0.05	917	11578	74944	951480	10265	110670	85209	1062150	4219	52419	89428	1114569	-9623	13247
	DEC 1	-234.50	220500	5472500																					
1					600	900	44200	66300	3.17	40192	1276711	1.17	21499	33077	69483	1020963	12973	123643	82456	1144606	4687	57106	87143	1201712	-24250	10822
	JAN 1	-234.30	221100	5516700																					
1												0.00										57106	0	57106	0	10822

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LTON,1972

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1960

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CU OT IN A
-	JAN 1	-234.30	221100	5516700																						
0					900	900	66300	66300	2.58	32800	32800	0.27	4975	4974.75	54553	54553	11218	11218	65771	65771	5324	5324	71095	71095	23030	23
	FEB 1	-234.00	222000	5583000																						
7					450	1350	33600	99900	5.04	64336	97136	0.15	2775	7750	77679	132232	10985	22203	88664	154435	4880	10204	93544	164639	1617	24
	MAR 1	-233.85	222450	5616600																						
9					900	2250	67200	167100	6.83	87362	184497	0.00	0	7750	99388	231620	10127	32330	109515	263950	6225	16429	115740	280379	38822	63
	APR 1	-233.55	223350	5683800																						
9					450	2700	33600	200700	9.74	125087	309585	0.00	0	7750	107896	339516	14662	46992	122558	386508	6239	22668	128797	409176	29890	93
	MAY 1	-233.40	223800	5717400																						
3					0	2700	0	200700	11.68	150304	459889	0.00	0	7750	94537	434053	10212	57204	104749	491257	6441	29109	111190	520366	39114	132
	JUN 1	-233.40	223800	5717400																						
4					-300	2400	-22400	178300	13.13	168963	628852	0.00	0	7750	87307	521360	8846	66050	96153	587410	6139	35248	102292	622658	44271	1767
	JUL 1	-233.50	223500	5695000																						
6					-750	1650	-56000	122300	13.86	178118	806970	0.06	1118	8867	98077	619437	8952	75002	107029	694439	6360	41608	113389	736047	7612	1843
	AUG 1	-233.75	222750	5639000																						
4					-450	1200	-33600	88700	12.70	162663	969634	0.00	0	8867	94896	714333	8938	83940	103834	798273	7251	48859	111085	847132	17978	2023
	SEP 1	-233.90	222300	5605400																						
0					-300	900	-22400	66300	9.83	125650	1095283	0.60	11115	19982	98554	812887	10511	94451	109065	907338	6604	55463	115669	962801	-23534	1788
	OCT 1	-234.00	222000	5583000																						
8					0	900	0	66300	8.27	105567	1200850	0.00	0	19982	106649	919536	9587	104038	116236	1023574	5282	60745	121518	1084319	-15951	1628
	NOV 1	-234.00	222000	5583000																						
9					450	1350	33600	99900	4.38	55911	1256760	0.75	13875	33857	75360	994896	9099	113137	84459	1108033	4936	65681	89395	1173714	-13759	1490
	DEC 1	-233.85	222450	5616600																						
0					300	1650	22400	122300	3.83	48989	1305749	0.10	1854	35711	64908	1059804	10096	123233	75004	1183037	4750	70431	79754	1253468	-10219	1388
	JAN 1	-233.75	222750	5639000																						
0												0.00										70431	0	70431	0	1388

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

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HESS GEOTECHNICAL CORP.

SALTON SEA WATER BUDGET ANALYSIS

SALTON SEA YEAR 1961

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L R T .	DATE	SEA ELEVATION FT.(-)	SEA AREA AC.	SEA VOLUME A.F.	CHANGE IN AREA A.C.	CUM'L AREA CHANGE AC.	CHANGE VOLUME MONTHLY A.F.	CUM'L VOLUME CHANGE A.F.	AVG. PAN EVAP INS	SEA EVAP MONTHLY A.F.	CUM'L EVAP A.F.	RAINFALL AVG. DIRECT INS.	SEA RAIN MONTHLY A.F.	CUM'L SEA RAIN A.F.	IID INPUT MONTHLY A.F.	IID CUM'L INPUT A.F.	MEXICO MONTHLY INPUT A.F.	MEXICO CUM'L INPUT A.F.	IID+MEX MONTHLY TO SEA A.F.	IID+MEX CUM'L INPUT A.F.	COACH. MONTHLY DRAINAGE A.F.	COACH. CUM'L INPUT A.F.	COACH+ IID+MEX MONTHLY A.F.	COACH+ IID+MEX CUM'L A.F.	OTHER SURFACE+ GRNDWTR INPUT A.F.	CL OT IN A
-	JAN 1	-233.75	222750	5639000																						
3					900	900	67200	67200	3.19	40858	40858	0.19	3527	3526.875	68152	68152	10338	10338	78490	78490	5168	5168	83658	83658	20873	20
	FEB 1	-233.45	223650	5706200																						
6					750	1650	56000	123200	5.05	64942	105800	0.00	0	3527	75833	143985	9405	19743	85238	163728	5331	10499	90569	174227	30373	51
	MAR 1	-233.20	224400	5762200																						
2					450	2100	33600	156800	7.17	92515	198315	0.03	561	4088	100972	244957	12148	31891	113120	276848	6548	17047	119668	293895	5886	57
	APR 1	-233.05	224850	5795800																						
8					550	2650	34000	190800	10.23	132262	330577	0.00	0	4088	102761	347718	11623	43514	114384	391232	7302	24349	121686	415581	44576	101
	MAY 1	-232.90	225400	5829800																						
2					-700	1950	-45200	145600	13.39	173541	504118	0.00	0	4088	97692	445410	10467	53981	108159	499391	7498	31847	115657	531238	12684	114.
	JUN 1	-233.10	224700	5784600																						
7					-300	1650	-22400	123200	12.65	163441	667559	0.00	0	4088	88727	534137	9240	63221	97967	597358	7260	39107	105227	636465	35814	150
	JUL 1	-233.20	224400	5762200																						
8					-150	1500	-11200	112000	12.71	163997	831557	0.00	0	4088	112904	647041	7726	70947	120630	717988	7316	46423	127946	764411	24851	175
	AUG 1	-233.25	224250	5751000																						
9					-450	1050	-33600	78400	12.56	161953	993510	0.85	15884	19972	89258	736299	10357	81304	99615	817603	9043	55466	108658	873069	3811	178
	SEP 1	-233.40	223800	5717400																						
8					-600	450	-44800	33600	10.96	141039	1134549	0.07	1305	21278	98834	835133	7775	89079	106609	924212	8645	64111	115254	988323	-20321	158
	OCT 1	-233.60	223200	5672600																						
9					-150	300	-11200	22400	8.36	107292	1241841	0.00	0	21278	100784	935917	9079	98158	109863	1034075	7248	71359	117111	1105434	-21019	1375
	NOV 1	-233.65	223050	5661400																						
9					150	450	11200	33600	5.51	70668	1312509	0.01	186	21464	75828	1011745	8721	106879	84549	1118624	6093	77452	90642	1196076	-8960	1285
	DEC 1	-233.60	223200	5672600																						
1					750	1200	56000	89600	3.30	42352	1354861	0.61	11346	32810	58955	1070700	9947	116826	68902	1187526	6442	83894	75344	1271420	11662	1402
	JAN 1	-233.35	223950	5728600																						
1												0.00										83894	0	83894	0	1402

NOTE: IF COACHELLA INPUT FOR MONTH NOT TABULATED, THEN "OTHER INPUTS" INCLUDE COACHELLA'S CONTRIBUTION.

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20-67

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1983

Contribution breakdown of Alamo and New River waters discharging into the Salton Sea.

Total to Sea for Year 1983	
(From within IID Service Area)	867,835

	ORIGIN	A.F./YR.	%
1.	Municipal-Industrial Contribution	12,000%	1.38
2.	Groundwater Intercept by Rivers & Deep Open Drains (Beneficial)	75,000	8.65
3.	Tile Drain Water (Beneficial)	245,000	28.26
4.	Required Soil Leach Water (Beneficial)	375,000	43.25
5.	Rainfall-Runoff (Average)	25,000	2.88
6.	Regulatory Canal Waste	35,000	4.05
7.	Canal Seepage (State of California Estimate, 1981)	100,000	11.53
	TOTAL	867,000	100.0

1. Based upon 125 gals./person/day living in urban areas (NAF included).
2. Groundwater origin, for the most part, thought to comprise parent groundwater irrigation return flow and mixtures thereof (1560 miles of open drains and 140 miles of river systems). Value is thought to be conservative.
3. Volume estimated based upon 1-year measurement program involving 10% of the acreage farmed within IID service area. Quality can vary each year, depending upon acreage farmed, single or double cropped.

NOTE: Total beneficial water = 695,000 or 80.16% of total water in the rivers.

4. 15% of the water delivered to farms has been established by the U. S. D. A. as the minimum quantity of "leach" water required for leaching salts and maintaining a proper on-going salt balance within the soil profile for a gravity-type irrigation system involving heavy soils and shallow saline groundwater (.15 x 2,500,000 A. F./Yr., or 0.815 A. F. of water/acre/year, or approximately 0.80-inches for each irrigation, which is sufficient to wet 1.50 inch depth of soil). Some of this water drains by gravity flow to the rivers.
5. Rainfall - runoff volume can reach as high as 50,000 A. F./Yr. Value used is equivalent to 1/2-inch rainfall over 640,000 acres.
6. 2% of total water in canal system.
7. On-going canal lining programs will reduce this amount on a gradual year-to-year basis. In certain areas this water is re-used for irrigation. Value was estimated by The State Department of Water Resources in report response to Elmore complaint of IID wasting water to the Salton Sea.

TILE DRAIN OUTLETS RECORDING PROGRAM

LOCATION & PERIOD OF RECORD	RECORD	Total A.F. For Period	A.F. Adjusted For 1-Year
Lat. "L" Del. 10 W			
11-02-82 to 11-02-83	55 Wks.	6.26	-
01-18-84 to 02-22-84	13 Wks.	3.14	-
	68 Wks.	9.40 A.F.	7.2
Lat. "L" Del. 10 E			
11-28-82 to 11-09-83	41 Wks	19.73	
11-16-83 to 02-22-84	13 Wks	5.97	
	54 Wks	25.70 A.F.	24.8
Lat "H" Del 10			
02-02-83 to 11-16-83	41 Wks	28.48	
11-30-83 to 02-22-84	14 Wks	6.59	
	55 Wks	35.07 A.F.	33.2
Nettle 1			
02-02-83 to 11-16-83	41 Wks	148.96	
11-30-83 to 02-22-84	14 Wks	25.33	
	55 Wks	174.29 A.F.	164.8
Malva 1 Del 1			
02-23-83 to 11-16-83	30 Wks	65.14	
11-15-83 to 01-18-84	9 Wks	10.79	
	39 Wks	75.93	101.2
Lat "M" Del 9			
11-21-82 to 11-16-83	56 Wks	192.06	
11-16-83 to 02-22-84	14 Wks	29.25	
	70 Wks	221.31	164.4
Munyon			
10-26-82 to 11-16-83	56 Wks	63.40	
11-16-83 to 02-22-84	14 Wks	6.41	
	70 Wks	69.81	51.9
Nectarine 4			
11-24-82 to 11-16-83	53 Wks	27.94	
11-16-83 to02-22-84	13 Wks	3.66	
	66 Wks	31.60	24.9
Acacia 55			
11-14-82 to 11-15-83	57 Wks	42.65	
11-15-83 to 02-14-84	14 Wks	6.33	
	71 Wks	48.98	35.9

TILE DRAIN OUTLETS RECORDING PROGRAM (Cont'd)

LOCATION & PERIOD OF RECORD	RECORD	Total A.F. For Period	A.F. Adjusted For 1-Year
Ash 157			
10-20-82 to 11-15-83	57 Wks	29.07	
11-22-83 to 02-21-84	14 Wks	3.08	
	71 Wks	32.15	23.6
Rubber 10			
11-08-82 to 11-15-83	48 Wks	25.18	
11-15-83 to 02-21-84	14 Wks	4.69	
	62 Wks	29.87	25.1
Lat. "D" Del 10			
02-21-82 to 11-16-83	42 Wks	29.83	
12-14-83 to 02-22-84	14 Wks	8.97	
	56 Wks	38.80	36.0
Tamarack 219			
02-01-83 to 11-15-83	27 Wks	28.64	
11-15-83 to 02-21-84	10 Wks	10.24	
	37 Wks	38.88	54.6
Mulberry 13			
11-01-82 to 09-28-83	55 Wks	70.28	
11-16-83 to 02-15-84	13 Wks	10.02	
	68 Wks	80.30	61.4
Lat. "G" Del 12			
02-02-82 to 11-16-83	41 Wks	44.48	
01-01-84 to 02-22-84	13 Wks	6.71	
	54 Wks	51.19	49.3
Thistle Main # 33			
02-01-83 to 11-15-83	39 Wks	33.34	
11-15-83 to 01-14-84	14 Wks	18.77	
	53 Wks	52.11	51.1
Magnolia 16			
02-02-83 to 11-16-83	41 Wks	12.10	
11-23-83 to 02-22-84	13 Wks	3.83	
	54 Wks	15.93	15.3
Magnolia 8			
10-28-82 to 11-16-83 (1-year only)	56 Wks	16.14	15.0

TILE DRAIN OUTLETS RECORDING PROGRAM (Cont'd)

LOCATION & PERIOD OF RECORD	Record	Total A.F. For Period	A.F. Adjusted For 1-Year
Mullen 24			
11-15-82 to 11-16-83	44 Wks	9.42	-
11-16-83 to 02-22-83	14 Wks	.80	
	53 Wks	10.22	10.0
Lat. "J" Del 8			
02-02-83 to 11-16-83	41 Wks	31.11	
12-28-83 to 12-22-83	14 Wks	2.61	
	55 Wks	33.72	31.9
Osage 0			
02-02-83 to 11-16-83	40 Wks	159.20	
11-16-83 to 02-22-84	14 Wks	35.87	
	54 Wks	195.07	187.8
Nectarine 6			
11-16-82 to 11-16-83	52 Wks	25.34	
11-16-83 to 02-22-84	14 Wks	35.87	
	56 Wks	30.63	28.4
Lat. C"C" Del 13			
02-02-83 to 11-16-83	42 Wks	34.18	
11-16-83 to 02-22-84	14 Wks	8.73	
	56 Wks	42.91	39.8
Nutmeg # 9			
11-24-82 to 11-02-83	52 Wks	14.12	
11-16-83 to 02-22-84	14 Wks	4.49	
	56 Wks	18.61	17.3
Thistle # 8 Del 12			
02--1-83 to 11-15-83	41 Wks	129.87	
11-15-83 to 02-21-84	14 Wks	21.23	
	55 Wks	151.10	142.9
Marigold # 3			
02-02-83 to 11-16-83	30 Wks	6.20	
11-16-83 to 02-22-84	14 Wks	8.33	
	44 Wks	14.53	17.2
Malva 2 Del 2			
02-02-83 to 11-16-83	39 Wks	8.79	
11-16-83 to 02-22-84	14 Wks	6.26	
	53 Wks	15.05	14.8

TILE DRAIN OUTLETS RECORDING PROGRAM (Cont"d)

LOCATION & PERIOD OF RECORD	Record	Total A.F. For Period	A.F. Adjusted For 1-Year
Lat. "D" Del 5			
03-09-83 to 11-16-83	17 Wks	22.68	
11-16-83 to 02-22-84	14 Wks	87.12	
	30 Wks	109.80	190.3
Acacia 56			
10-29-82 to 11-15-83	48 Wks	12.64	
11-15-83 to 02-21-84	12 Wks	.37	
	60 Wks	13.01	11.3
Trifolium 6 Del 114			
02-22-83 to 09-27-83	17 Wks	19.15	
11-29-83 to 02-21-84	8 Wks	1.94	
	25 Wks	21.09	43.9
Trifolium 8 Del 152A			
03-22-83 to 09-20-83	11 Wks	2.17	
02-14-84 to 02-21-84	1 Wk	1.96	
	12 Wks	2.17	9.4
Trifolium 9 Del 179			
02-01-83 to 11-15-83	31 Wks	46.14	
11-29-83 to	12 Wks	1.96	
	43 Wks	48.1	58.2
Township 20			
02-01-83 to 11-15-83	41 Wks	53.75	
11-15-83 to 02-21-84	14 Wks	8.72	
	55 Wks	62.47	59.1
Tamarack 223			
02-01-83 to 11-15-83	40 Wks	2.16	
11-15-83 to 02-21-84	14 Wks	.99	
	54 Wks	3.15	3.0
Trifolium 4 Del 75			
06-10-83 to 11-15-83	23 Wks	8.83	
11-15-83 to 02-21-84	14 Wks	3.00	
	37 Wks	11.83	16.6
Orange 22			
02-01-83 to 10-04-83	34 Wks	14.36	
12-06-83 to 02-21-84	11 Wks	8.84	
	45 Wks	23.20	26.8

TILE DRAIN OUTLETS RECORDING PROGRAM (Cont'd)

LOCATION & PERIOD OF RECORD	Record	Total A.F. For Period	A.F. Adjusted For 1-Year
Ohmar 24			
02-01-83 to 11-15-83	41 Wks	9.69	
11-15-83 to 02-21-84	14 Wks	7.94	
	56 Wks	17.63	16.7
Oak 25			
02-02-83 ti 11-15-83	42 Wks	38.67	
11-15-83 to 02-21-84	14 Wks	12.13	
	56 Wks	50.80	47.2
Orient 5			
02-01-83 to 11-15-83	39 Wks	49.97	
11-15-83 to 02-21-84	14 Wks	15.79	
	53 Wks	65.76	64.5
Evergreen 23			
10-22-82 to 10-25-83	56 Wks	8.22	
11-15-83 to 02-21-84	13 Wks	4.12	
	69 Wks	12.34	9.3
Ash 156			
10-20-82 to 09-27-83	27 Wks	4.31	
01-24-83 to 02-07-84	2 Wks	.009	
	29 Wks	4.31	7.7
Pine 24			
06-13-83 to 10-25-83	18 Wks	4.46	
11-15-83 to 02-21-84	14 Wks	12.58	
	32 Wks	27.04	43.9
Lat 13 Del 294			
06-10-83 to 11-15-83	22 Wks	10.58	
11-15-83 to 02-21-84	14 Wks	2.58	
	36 Wks	13.16	19.0
Marigold 8			
11-16-83 to 02-22-84	14 Wks	2.86	10.61

2067.3.

TOTAL WEEKS RECORDED : 2246

TOTAL DAYS RECORDED : 15.722

Average days records/outlet monitored : 51 weeks
357 Days

HESS GEOTECHNICAL CORP.

TENTATIVE

NOT FINAL

APRIL 1984

TILE WATER MEASUREMENT PROGRAM

PERIOD OF MEASUREMENT:		Last three months of 1982 All of 1983 First two months of 1984
Total Number of Sumps in Program	:	237
Total Number of Tile Outlets in Program	:	44
Total Acreage in Program	:	49,554 (10% of total within IID Dist.)
Total Net Irrigated Acreage (1983)	:	445,925 Ac.
Adjusted Tile Water (Total Acreage)	:	227,669 A.F.
Percent Decrease in Irrigated Acreage due to P. I. K. Program (1983)	:	7%
Adjusted (Upward) Tile Water for non-P. I. K. Program Year	:	245,000 A.F.
Percent Tile Water of Total Water to Sea From Within IID Service Area	:	29.1%
Estimated Other Contributions to the Sea via New/Alamo Rivers :		
Municipal Waste	:	12,000 (1.4%)
Groundwater Intercept by Open Drains	:	50,000 A.F. (5.9%)
Required Leach Water (15%)	:	375,000 A.F. (44.5%)
Regulatory Canal Waste	:	35,000 A.F. (4.2%)
Canal Seepage, State Estimate	:	100,000 A.F. (11.9%)
Rainfall	:	25,000 A.F. (3.0%)
TOTAL	:	842,000 A.F.
TILE WATER	:	867,835 A.F.

Benefical Water : Tile (245,000) + Leach (375,000) + Groundwater Intercept (50,000) = 670,000 A. F. (77.2%)

HESS GEOTECHNICAL CORP.

ELECTRICAL CONDUCTANCE VALUES (U-MHOS)

FOR

TILE DRAIN WATERS

	1983 Nov.	1983 Dec.	1984 Jan	1984 Feb.
Evergreen 23	14,000	13,000	12,200	8,507
Rubber 10	8,200	8,000	5,700	5,580
Acacia 56	* ---	6,600	5,200	6,418
Acacia 55	4,300	4,420	3,780	4,785
Ash 156	---	---	---	8,306
Ash 157	6,800	7,000	5,800	5,952
EHL 13, Del. 294	1,820	1,820	15,700	3,329
Pine 24	---	16,800	14,100	1,415
Township 20	17,400	17,800	14,800	1,190
Orient 5	9,800	10,200	7,800	8,117
Orange 22	---	---	12,200	9,747
Ohmar 24	6,400	8,200	7,800	7,342
Oak 25	12,000	12,700	9,400	8,375
Tamarack 223	19,200	18,200	15,000	12,468
Tamarack 219	---	4,680	---	---
Trifolium 4, Del. 75	6,800	5,200	2,750	4,156
Trifolium 6, Del. 114	---	---	---	---
Trifolium 8, Del. 152A	---	---	---	---
Trifolium 9, Del. 179	6,000	---	---	3,695
Thistle 8 Del 12	7,100	7,000	5,300	6,305
Thistle Main 33	7,200	7,800	5,400	6,024
Osage 0	1,620	1,720	1,280	1,817
Magnolia 16	10,200	10,800	8,900	10,730
Mullen 24	8,800	9,700	---	2,914
Mulberry 13	8,900	11,800	8,800	7,246
Munyon 14	12,200	13,100	7,600	9,242
Malva 1 Del. 1	5,800	7,300	3,820	---
Malva 2 Del. 2	4,630	4,820	4,280	4,831
Marigold 3	4,600	5,300	4,720	4,873
Marigold 8	29,300	31,600	23,200	16,722
Nettle 1	6,000	6,200	4,430	5,643
Nutmeg 9	18,400	17,600	14,300	11,062
Nectarine 4	11,200	11,400	9,000	8,375
Nectarine 6	24,800	25,800	21,800	16,234
Lat. C. Del. 13	31,200	32,000	21,100	17,007
Lat. D. Del 10	15,400	11,200	10,000	9,090
Lat. D. Del 5	3,880	3,280	2,920	3,348
Lat. G. Del 12	11,200	9,800	10,400	7,653
Lat. H. Del. 10	12,200	13,200	10,200	8,929
Lat. J. Del. 8	10,300	9,700	7,600	8,306
Lat. L. Del. 10E	5,700	5,300	3,800	4,965
Lat. L. Del. 10W	8,200	6,200	4,780	4,505
Lat. M. Del. 9	4,880	4, 770	3,670	4,505

* --- = No discharge

HESS GEOTECHNICAL CORP.

April, 1984

IRRIGATION INPUT/OUTPUT RATIOS

FIELD	Irrigation Input A.F.	WATER Tilewater Effluent A.F.	SALINITY Output Input %	1983-1984 Conductance U-MHOS Nov.	Dec.	Jan.	Feb.
E.H.L. Lat. 10 West	10.2	0.64	6.3	8200	6200	4780	4505
E.H.L. Lat 10 West	28.6	0.25	.28				
E.H.L.Lat 10 East	30.2	0.92	3.1	5700	5300	3800	4965
E.H.L.Lat 10 East	10.2	2.0	19.7				
Magnolia 16	24.4	1.87	7.68	10,200	10,800	8900	10,730
Magnolia 16	34.0	1.63	4.79				
Magnolia 16	30.0	1.01	3.35				
Magnolia 16	12.0	1.09	9.05				
Malva.1, Del 1	39.6	5.48	13.83	5800	7300	3820	
Malva 1, Del 1	36.2	2.56	7.06				
Malva 1, Del 1	44.0	9.83	22.33				
Acacia 55	23.6	2.22	9.39	4300	4420	3780	4785
Acacia 55	23.8	0.86	3.63				
Acacia 55	24.2	1.87	7.74				
E.H.L. Lat H #10	110.8	8.32	7.51	12,200	13,200	10,400	8929
E.H.L.Lat H # 10	110.8	9.83	8.87				
E.H.L. Lat H #10	88.2	5.15	5.83				
Munyon 14	12.2	1.71	13.93	12,200	13,100	7600	9242
Munyon 14	12.2	2.15	17.61				
Thistle Main #33	12.0	1.45	12.05	7200	7800	5400	6024
Lat D, #10	55.4	1.81	3.27	15,400	11,200	10,000	9090
Lat D, #10	51.0	1.63	3.19				
Lat D, #10	48.0	2.24	4.66				
Lat M #9	72.2	20.62	28.56	4880	4770	3670	4505
Lat M, #9	48.4	6.73	13.91				
Lat M #9	48.6	8.91	18.34				
Lat M #9	30.8	12.43	40.35				
Rubber #10	20.6	1.09	5.29	8200	8000	5700	5580
Rubber #10	20.0	.70	3.48				
Lat G, #12	7.16	7.84	10.95	11,200	9800	10,400	7653
Nectarine 4	77.0	1.24	1.61	11,200	11,400	9000	8375
Tamarack 219	39.2	1.83	4.67	12,200	4680	----	----
Ash 157	12.6	1.34	10./67	6800	7000	5800	5952
Lat G, #12	50.4	1.79	3.55	11,200	9800	10,400	7653

NOTE: Irrigation input and output Q values may reflect multiple contiguous irrigation cycles.

Conductance blanks are repeats

TOTAL INPUT = All water delivered to gates.

20-68

HESS GEOTECHNICAL CORP.
EL CENTRO, CALIFORNIA 92244

June 8, 1984

Mr. Charles Shreves
General Manager
Imperial Irrigation District
P.O. Box 937
Imperial, CA 92251

Dear Mr. Shreves:

The following information has been developed pertinent to our study involving quantifying tile drain water contributions to the Salton Sea via the New and Alamo Rivers for the year 1983.

Total Number of Tile Sumps in IID Program:	237
Total Acreage Represented by Sumps:	44,249 AC.
Total Number of Tile Outlets in IID Program:	45
Total Acreage Represented by Tile Outlets:	5,305 AC.
Total Acreage within IID Service Area: (Based upon 10% of acreage used in monitoring program)	495,540 AC.
% of Monitored Acreage in Sump Program:	89.3
% of Monitored Acreage in Tile Outlet Program:	10.7
Total = 100% or 49,554 AC.	
Total measured discharge, all sumps monitored (1983). Based upon quarterly discharge measurements. Values prorated to 365-days in some instances:	21,586 A.F.
Total measured discharge, all tile outlets monitored (1983-1984). Based upon continuous recorder measurements. Values extrapolated to 12-months in some instances:	1,932 A.F.
Total discharge - all sumps and tile outlets, 12-month period:	23,518 A.F.
Total discharge all tile lines adjusted for 100% of acreage.	235,180 A.F.

Sump discharge measurements were made quarterly during 1983. Tile outlet program consisted of continuous recording of tile outlet flow, over a 12-month period between February 1983 to February 1984.

Tile waters represent: parent ground water, deep percolation modified irrigation water recovered by tile lines, as well as combinations thereof. Portions or all of the waters may be considered beneficial. Chemical analyses of tile waters have been made in an effort to establish the source (origin) and to quantify the contributions in each category. However, to date, the work has not extended much beyond the analytical stage.

No attempt has been made to adjust the tile discharge figures to reflect any planted 1983 acreage decrease which might have resulted under the P.I.K. program.

A summary of other ancillary work will be forwarded shortly.

Yours truly,

HESS GEOTECHNICAL CORPORATION

John D. Hess
President

20-69

E

MATERIALS ENGINEERING
APPLIED SOIL MECHANICS
AGRICULTURAL INVESTIGATIONS
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EL CENTRO, CALIFORNIA 92243

T

March 12, 1982

Ted H. Lyon, Inc.
1450 Broadway
El Centro, CA 92243

Dear Mr. Lyon:

The State of California Department of Water Resources has identified a number of ways in which the Imperial Valley farming community and the Imperial Irrigation District can take steps to reduce irrigation waste to the sea, as well as increase water use efficiency. One of the methods proposed considers modifying the land leveling practices currently used in the valley and the use of a "dead-level" irrigation technique.

As you are well aware the "dead-level" irrigation approach has not appealed to valley farmers for the following reasons:

1. Natural slope is to the sea basin and any major changes in natural slope will be cost prohibitive.

2. Tailwater is required and mandatory for salt leaching purposes (15% or greater of that applied or available at the farmer's headgate).

3. Tailwater is required for low "K" soil profiles for drainage of surface water, prevention of scalding and drowning of crops.

I would like a written proposal from your firm covering a report addressing the following areas of land leveling and associated irrigation effects thereof.

m

A. Pros and cons of dead-level vs. slope irrigation
   (a) Heavy soil profiles (imperial clay)
   (b) Light soil profiles (silty loams)
   (c) Sandy soil profiles
   (d) Stratified soil profiles

B. Address the history of land leveling practices used in the valley for the past 50 years. Compare methods currently used with those of other areas in the southwest desert.

C. If you are aware of any so-called "dead-level" practices being used in the valley, describe them in detail (primarily land releveled to "dead-level").

D. Suggested new approaches to land leveling in order to increase efficiency in the use of water.

I have set your fee schedule at $45.00 per hour. Please invoice us each month.

A short response, 3-5 pages, will be required by April 30th with a complete report required at a later date, yet to be determined.

All reports must be submitted in rough draft form, followed by a second report which is to be bound. Cover letters must be addressed to the undersigned. Title of the reports shall be: Land Leveling Practices in the Imperial Valley 1940-1982.

Your report should incorporate history, current practices as well as criticism thereof, and suggested corrective measures. Feel free to provide "new blood" but be sure that any such areas can withstand scrutiny, defense, etc.

In addition we will also need a brief background history of you, your new company, as well as those you plan to participate in the project.

Yours truly,

JOHN D. HESS TESTING CORPORATION

John D. Hess
President

P.S. Written notice will be given to you to proceed after receipt and approval of your proposal.

cc: Gerald Moore
    Robert Carter

20-70

F

August 16, 1977

acreage limitation

Mr. Guy R. Martin
Alternate to the Chairman
Water Resources Council Chairman
Water Resources Policy Committee
2120 L Street, N. W.
Washington, D. C. 20036

Dear Mr. Martin:

Due to the extremely short notice afforded, the Imperial Irrigation District has been prevented from preparing a comprehensive response to the four issue papers emanating from the Water Resources Policy Study as published in the Federal Register, Volume 42, No. 136, Friday, July 15, 1977. For your information, representatives of Imperial Irrigation District attended the July 28-29 hearing at the Marriott Airport Hotel in Los Angeles. Although the presentations were enlightening, it was extremely difficult to agree with some of the conclusions raised by several of those who appeared before you.

For example—and to clear the record--Marilyn Stout testified that Imperial Irrigation District sold water for $2.00 per acre-foot, when in fact the rate today is $4.75 per acre-foot plus a $1.42 per acre per annum assessment charge for water availability. Water duty per net acre irrigated in Imperial Valley exceeds an average of 6 acre-feet per acre per year when on the other hand, the Court's record of facts in Arizona vs. California reveals all Indian lands along the Lower Colorado River were decreed a right of 6.9 acre-feet per acre per year as a reasonable beneficial amount of water to maintain these lands at their maximum productive capability. This was considered by the Court and all the states who were parties to that action as a reasonable beneficial quantity of water demanded to operate the systems.

To clear the record with respect to testimony given by Marilyn Stout addressing the matter of acreage limitation, the statement was made that acreage limitation should apply to all lands in the United States and that 20 acres of land in Germany could sustain a family as compared to 100 acres in Iowa. This may or may not be true as concerns Germany or the State of Iowa; however, the record developed by the University of California in 1971 and introduced as evidence in the matter of Yellen vs. Hickel, states that: "The increases /in average returns/ for units with substantial machinery inventories is much larger. For example, Size III farms /1,000-1799 acres/ show returns per acre rising from $51.82 at 454 acres to $73.79 at capacity of 1,518 acres for a total increase of $23,376.08 due solely to gains achieved by economies of size... size III farms give highest returns to land per acre through its range of acreage. Maximum returns per acre of about $74.00 are attained over a wide range of 1,500 to 2,500 acres."

Furthermore, the United States pressed the issue to determine the validity of the acreage limitation law in its application to Imperial Irrigation District and was struck down by the United States District Court when the judge ruled in favor of Imperial. The judge for the most part based his ruling on the fact that good faith reliance upon the determination of a cabinet level officer in 1933 should not and could not be abrogated by a position taken by a successor of 33 years hence. It would be particularly nauseous to the public agency administering the water contract for the people it serves--including all cities, schools, businesses, landholders, and improvement districts who are pledged to paying for the project--for the government to be able with one stroke of the pen to erase the very basis upon which the area's economy was established as if that foundation never existed. The Court felt that the people who reside in Imperial Valley relied on the commitment of the Secretary of Interior in 1933 and it could not and should not be overturned.

Turning to the matter of the Water Resources Policy Study Hearing, Imperial Irrigation District submits the following:

> We believe there is a need for a comprehensive review of water resource policies and for changes that would better accommodate the available source to the prevailing and future needs. This is not to say that a doctrine of first in time, first in right, or those having a vested and/or present perfected right, should be disturbed by redistribution unless, of course, sound conservation practices are not being employed.
>
> Imperial Irrigation District, in my judgment, has a fine record o with respect to conservation, and listed below is a 13-point water conservation program initiated by the Board of Directors over a year ago, which to date is proving to be viable and productive.
>
> (1) Construction of No. 8 Pond. (This is a 600 acre-foot Water Conservation Storage Reservoir, the second to be completed in the past two years with a third on the drawing board as can be seen by (6) below).
>
> (2) Reconstruct, to the extent necessary, all waste boxes in system. (These are the tail-water outlet boxes located on the low corner of cultivated fields by which excess runoff is measured and which forms the basis by which penalties are assessed in accordance with (4) below).
>
> (3) Recruitment and employment of an adequate number of water regulating personnel to schedule changes in water deliveries to water users as requested as the system will permit.

(4) An inventory of surface field discharge water will be taken daily and an assessment may be levied against all discharges which equal 15% or more of the water being delivered and measurement thereof shall have been taken on two successive occasions not less than nine hours apart in a 24-hour period. The term assessment used herein shall mean the quantity of water ordered in second feet and reduced to acre-feet, times the scheduled water rate multiplied by 3 for the day in which the measurements were taken. (In other words, the wasting user is paying three times the regular charge).

(5) Surface pond development through evaporation.

(6) Acquisition of land to construct reservoir on Central Main Canal in the vicinity of No. 4 Heading.

(7) Study relating to water recovery lines paralleling the East Highline and Westside Main Canals for seepage recovery which is now going into drainage system and to Salton Sea. (Approximately 18,000 acre-feet of water per year is presently being salvaged by existing water recovery lines paralleling the East Highline Canal).

(8) Free drainage water to any person willing to pump and use same.

(9) Continuation of concrete lining program.

(10) The initiation of record to reflect accrued water use per parcel through computerized billing process for period July 1 to June 30 of each year.

(11) Accelerated program to install radio equipment in all water conservation related mobile equipment for immediate exchange of information with supervision and Water Control Section.

(12) Immediate initiation of irrigation management services program.

(13) Delivery of water off-schedule when and wherever possible.

The Imperial Irrigation District has been very conscious through the years of its overall water use efficiency. The U. S. Bureau of Reclamation has also maintained records of water use efficiency of the various agencies for many years, and their records show a water use efficiency factor (water delivered to farms divided by water received at Drop 1 on the All-American Canal x 100) of 84.5% in 1962, increasing to 89.5% in 1976. When the water delivered to cities is included, the percentage is even higher being 90.4% in 1976.

Of course, the above percentages include an approximate 20% leaching factor which is imperative due to the high salinity content of Colorado River water, which contains 900 to 1,000 p.p.m. of dissolved solids when received by the District. These minerals for the most part are deleterious to crops, and due to the fine-grained Imperial Valley soils, additional water must be applied to leach the mineral-laden water below the root zone where it is collected and removed by subsurface tile drain lines. Leaching "is a sound irrigation practice. You have to leach out your soils...I think I can say very straightforwardly that the normal leaching associated with sound agricultural practices will have to continue," according to former Secretary of Interior, Stewart Udall, testifying before a Congressional Committee on HR 3300 and S 20 in 1967. In the same hearings, then Commissioner Floyd Dominy said "...I think Imperial Irrigation District, for example, has a very commendable record, because all of the research work in Riverside and other irrigation and agricultural experimental stations indicate that on soils of the type that you have in the Imperial Valley and the ground water conditions that prevail there, you need an override in your irrigation delivery to the farm of something in the order of 23 to 25% in order to take care of the leaching requirements and keep the land in cultivation."

The comments of Secretary Udall and Commissioner Dominy were in response to charges that Imperial Irrigation District wastes water. That was ten years ago, and the same charges are still being made today by the uninformed, by those who, though furnished with the facts, refuse to understand or recognize the unique nature of the Imperial Valley and make such unsubstantiated charges as those quoted from a report of former California Assemblyman Charles Warren, now chairman of the President's Council on Environmental Quality which states: "Information gathered so far indicates there is reason to believe that Imperial Irrigation District is dumping fresh water into Salton Sea."

One must realize that this Valley is different from most in that it lies adjacent to and downgrade from the vast Mexicali Valley in the Country of Mexico and receives drainage from that area including raw sewage. Imperial Valley receives its water supply by gravity flow entirely from the Colorado River via the 80-mile long All-American Canal. There is no opportunity for return flow to the River in that the natural drainage is northward to the Salton Sea by way of the Alamo and New Rivers, the latter of which is an interstate stream by definition and accepts drainage water from approximately one-half of Imperial Valley farms including the water from Mexicali mentioned above. The quality of that water at best is polluted brackish and saline, certainly not fresh by any standard. In fact, it contains up to 7,000 p.p.m. of dissolved solids at certain times of the year.

Referring once again to the necessity for maintaining a favorable salt balance in Imperial Valley, vis-a-vis the combined problems of poor quality water supply, the tight soils, and the necessity for installing underground drain lines to prevent water-logging and salt-buildup in the root zones. The quality of Colorado River water is degrading, index-wise, and the leaching factor will rise, which will require additional water each year if a favorable salt balance is to be maintained.

In regard to the quality of the water in the New and Alamo Rivers discharging into Salton Sea, the same will continue to degrade and the problem will continue to compound due to the continued installation of farm subsurface drain lines to the extent of some 350 miles per month for accumulative total to date in excess of 24,000 miles.

May I say just a word about the cost involved in maintaining the Imperial Valley farms at their highly productive state in producing food and fiber as a substantial input into the nation's economy. Imperial Valley is the fourth highest producing county in California and fifth in the nation. In testimony before the House of Representatives Interior and Insular Affairs Subcommittee on Water and Power Resources in 1974 (H.R. 12165), the District's spokesman stated and I quote: "In reviewing the records, we find the quality of water coming into our system as late as 1953 averaged 600 p.p.m. at a minimum, while today we are required to use water which averages approximately 900 p.p.m. The battle against salinity has been a continuous one. Of the 444,000 agricultural acres referred to previously, 383,000 acres had subsurface tiling installed by the end of 1973, at a cost of $43,759,700 leaving 59,000 acres to be tiled, which will cost an additional $25,400,000 thus representing a total capital investment of $69,159,700.

"In 1968, Imperial Irrigation District presented testimony before the Subcommittee on Irrigation and Reclamation of the House of Representatives Committee on Interior and Insular Affairs during hearings concerning bills H.R. 3300 and S.B. 1004. On page 884 of the transcript of these hearings T-1044 entitled 'Salinity of Irrigation Water Received by District and Leaching Requirement, 1964-1966...' indicates that 926 p.p.m. water requires a leaching factor of 22%.

"During the same hearings, Mr. Floyd E. Dominy, Commissioner, Department of Interior, Bureau of Reclamation, stated that, Our judgment at the moment, collective judgment of the Geological Survey and the water pollution people and the Bureau of Reclamation in the Department, would be that with full Upper Basin development the water quality at Imperial Dam would gradually worsen to probably something like 1,400 parts per million of dissolved minerals."

In a 1973 letter to the Colorado River Board of California, the general manager of Imperial Irrigation District reported a cost for concrete lining of District lateral canals of $10,341,950 through 1972 and that the landowners had invested $15,893,000 for concrete lining of private farm ditches up to that time. The program of lining District's lateral canals is approximately one-half completed, and it was estimated at that time that an investment of $28 million would be required to complete the project which is being accomplished at the rate of approximately $2 million per year.

In regard to Issue Area No. 4 Water Conservation A. "The price of water is insufficient to provide incentives necessary to promote efficiency and prevent wasteful uses," may I say that the Imperial Irrigation District has demonstrated that to pay-as-you-go from revenue produces the best economical position to the rate payers, whether it be for water or for power, for the simple reason that no interest is involved. Furthermore, the District has always believed that to administer its affairs on its own is far superior to seeking relief from the United States, which is already overburdened. As a matter of fact, the District's capital improvements in water and power have been accomplished largely on a pay-as-you-go basis, permitting our users to enjoy the lowest power rates in the Southwestern United States. We cannot say the same in regard to the rates our water users pay, however.

The Imperial Irrigation District is considered by the U. S. Bureau of Reclamation as a model irrigation district, and they schedule approximately 300 foreign visitors annually to inspect the works and operations of the District. For example, in testimony before the House Subcommittee on Irrigation and Reclamation in 1968 (H.R. 3300 and S.B. 1004) U. S. Bureau of Reclamation Commissioner Floyd Dominy stated in a colloquy with then Congressman John Tunney that: "You are quite correct, Congressman Tunney, that this drainage water from the Imperial Irrigation District is not considered usable. It has a minimum of 3,000 parts per million of dissolved solids as it flows out of the salty lands of Coachella and Imperial. Many days, it runs about 4,000 parts per million. But as explained the other day, I do not think anyone familiar with the type of soils to be irrigated would consider this waste water. A great deal of research has been done on lands of this type--and incidentally, the Imperial and Coachella Valleys are laboratories for salted lands for the whole world. People are coming in ever-increasing numbers to study the manner in which successful irrigation has developed on lands of this character." (emphasis added)

In regard to Issue 4 Water Conservation, Problem A: None of the 5 Options allows for local regulation concerning water pricing. Please refer to Item 4 of the District's 13-point water conservation program delineated earlier in this letter.

Regarding Issue 4, Problem B "Inadequate consideration has been given to meeting existing water needs by means of comprehensive watershed management practices, including storage and transfer of surplus water derived from existing supplies," Option 3 seems like the best option to pursue. The District has two such water reservoirs in operation and a third is in the planning stage (see items 1 and 6 of the District's 13-point water conservation program).

As concerns Issue 4, Problem C, Option 2 would be acceptable if it read "Encourage all users..." instead of "Require all users..." As an alternate to Option 3, local cooperative programs should be encouraged to establish priorities for water supply allocations, although perhaps such allocations should be required for new Federal projects. I refer you to Item 8 of the District's 13-point water conservation program which provides for free use of drainage water for anyone willing to pump and reuse same. The District is also cooperating in establishing several model pump-back systems for water reuse and has entered into an agreement with the United States government involving the use of neutron probes for determining soil moisture needs.

As to Issue 4, Problem D "Ground water supplies are poorly regulated and are being seriously depleted in some areas through excessive withdrawals," I am sure you have gathered from the above comments on the need for subsurface drainage that Imperial Valley has no usable groundwater reservoir due to the high saline content of same.

Area No. 4: E. regarding, "Inefficient use of water in existing water-consuming facilities and production processes..." including the sector of "agricultural irrigation practices...spillage, leakage and waste," I believe the District and its water users are making substantial progress in this direction via items 2, 3, 4, 7, 8, 9, 10, 11, 12, and 13 of the previously referenced 13-point water conservation program. Furthermore, we fully support Option 1.

We do not believe that the State of California should lose its identity with respect to water policies patterned after State codes, and to think of a federal commission administering the affairs of the State from a seat in Washington, D. C., is unconscionable. The State being much closer to the problems, i.e., use of water, quality, quantity, regulation, conservation, and other related issues, is much more apt to be in a position of employing fair, impartial and equitable means and measures to obtain the desired result in harmony with a nationwide effort in water resource planning.

Each area, each district, each entity, has its own problem, circumstances and needs peculiar to its locale. It would be entirely different from the operations of a similar district in an area to the north, east, or south of the California borders.

As concerns Indian lands and water rights, we do not quarrel with the decree in Arizona vs. California in respect to the quantity of water allotted to the Indians, for the decree addresses itself to a specified quantity. The decree also provides a remedy for assistance, if a remedy is in order and is required.

Since the matter of Indian rights is the responsibility of the Bureau of Indian Affairs--a branch of the Department of Interior--and the Department of Justice, certainly what has been accomplished in the past must have been fair, for the Bureau of Indian Affairs and the Department of Justice represented the Indians with all due diligence and expertise, though some may now argue to the contrary.

In summary, it would be an understatement to say that Imperial Irrigation District appreciates its right to use the invaluable resource--water. It has in the past and will continue in the future to cooperate with any viable, practical and productive effort to conserve water and use it as beneficially as possible in light of natural and/or uncontrollable circumstances. However, we do not believe that the establishment of rigid national policies to be administered on a national basis will be workable, equitable, or particularly productive.

Yours very truly,

GERALD L. MOORE, President
Board of Directors

gar
bcc Mr. Carter
Mr. Twogood

20-71

T F

AR 6-22-80

Congress' decision will dam dilemma over irrigation rights

By Carle Hodge
Republic Staff

After 78 years, Congress finally will increase the number of acres of land that a landowner can irrigate with federal reclamation project water.

The congressional dilemma is, what should be the bounds?

Should a farmer be held to 1,280 irrigated acres as the Senate has said, or the 960 acres currently proposed in the House of Representatives?

A University of Arizona agricultural economist said he believes a single answer is elusive. How much land a grower needs differs with time and place, Dr. Roger A. Selley says.

Meanwhile, the U.S. Supreme Court muddied the conflict last week by upholding most existing water rights in the area where the current "limit" has been exceeded most widely: California's lush Imperial Valley.

That decision probably poses no immediate impact on Arizona agriculture.

But what Congress does certainly will affect Yuma and Maricopa counties, where 114 farmers are watering 33,054 acres beyond the 160 to which each supposedly is entitled.

The 160-acre maximum was dictated by the Reclamation Act of 1902.

Last week, the high court reversed a 1977 9th U.S. Circuit Court ruling that restricted the Imperial land irrigable with Colorado River water to parcels no larger that those the 1902 act allowed.

The opinion, written by Justice Byron R. White, covered 233,000 acres there on which water rights had been established in 1929.

The Supreme Court sent back for argument in lower courts the fate of an additional 14,022 acres in the valley on which the rights were obtained after 1929.

White said that the Boulder Canyon Project Act, effective in 1929, exempted the Imperial Valley land from the acreage limit.

Water turns desert fertile

Had the 1977 ruling stood, it would have led to the sale of many farms at less than market prices, the court noted.

The 230,000 acres in question, roughly between the border at Mexicali and the Salton Sea on the north, are owned in plots larger than 160 acres.

Many of them are owned by Chevron, Southern Pacific, Purex and other conglomerates.

A forlorn desert until then, the Imperial Valley was turned into a rich garden by the arrival of water from the Colorado in 1901.

River water has been diverted into the valley since 1942 by the government-constructed All America Canal.

In Arizona, the greatest concentration of "excess" land is in Maricopa's Roosevelt Water Conservation District. There, 70 farmers are using 15,617 such acres.

For the Wellton-Mohawk project east of Yuma, the comparable figures are 24 farmers and 12,457 acres.

And around Yuma are 20 farm operators with 4,980 "excess" acres.

By California standards, for example, these are not large areas.

Some officials estimate that of the 12 million federally irrigated acres in 17 states, perhaps 1 million are irrigated illegally — or were before the Supreme Court decision.

Congress has been grappling with attempts to revise the restraints.

The House Interior Committee, whose chairman is Rep. Morris Udall, D-Ariz., agreed Friday to boost the 160-acre limit to 960.

The Senate last year decided on 1,280 acres.

Udall has said he hopes the full House can pass the bill and a compromise can be reached with the Senate version by the end of 1980.

The way it is written now, Interior Secretary Cecil Andrus ardently opposes the legislation.

160 acres are not enough, expert says

To him, it's "a substantial setback to family farming" and a boon to "new large-scale irrigation uses of federally subsidized water at bargain rates."

Selley, on the other hand, points out that 160 acres simply are not enough to allow many farmers to recoup their investments and make a living.

In the Wellton-Mohawk project, he said, a farmer needs a minimum of 320 acres.

The average farm there now encompasses 333 acres.

Selley and a colleague at the university, Dr. James O. Wade, took part in a U.S. Department of Agriculture analysis of 18 irrigation projects in the West.

One object was to determine how large a farm must be to minimize costs and prove competitive economically.

"Generally speaking, the study shows that seven of 18 projects were losers for a beginning farmer with anything less than 640 acres," Selley said.

But he added that the acreage required depends on climate, soil and other variables.

"Depending upon what a farmer grows, the limit could be as low as 40 acres or it could be at least 1,000."

"It is a political question," he said. "If I were a congressman in New York City, I'd look at it much differently than if I were a congressman from Casa Grande."

20-72

F

TELEPHONE (619) 339-0646

IMPERIAL IRRIGATION DISTRICT

EXECUTIVE OFFICE • 1284 MAIN STREET • ~~P.O. BOX 1809~~ • EL CENTRO, CALIFORNIA 92244

mjc 6/1/95

May 30, 1995

VIA FEDERAL EXPRESS

Mr. Ronald J. Schuster (D-5010)
Westwide Settlement Manager
Bureau of Reclamation
P.O. Box 25007
Denver, Colorado 80225

Re: Draft Environmental Impact Statement on Proposed Acreage Limitation and Water Conservation Rules and Regulations

Dear Mr. Schuster:

Thank you for the opportunity to comment on the draft Environmental Impact Statement (EIS) on the proposed Acreage Limitation and Water Conservation Rules and Regulations. Imperial Irrigation District (IID) recently commented on the proposed rule as published in the Federal Register on April 3, 1995 and on the draft Water Conservation Guidelines and Criteria. In lieu of restating our prior comments, we have attached our letter to you dated May 24, 1995, and our letter addressed to Commissioner Daniel P. Beard dated April 5, 1995. The comments included in those two letters should be incorporated in these comments on the draft EIS as if fully set forth herein. Additionally, IID would like to make the following comments.

The draft EIS does not acknowledge the need for additional water for leeching soils in order to reduce soil salinity. Instead, the draft EIS seems to assume that excess salt will build up in soils, leading only to retirement of land. However, good farming practices and soil conservation management techniques dictate the use of additional water to leech salts from soil. By employing this management technique, farmers conserve agricultural soil and land. Leeching also allows farmers to avoid secondary effects, such as air quality degradation and third-party impacts, which occur when land is fallowed.

The discussion of incentive pricing on pages 4-12 and 4-13 implies that incentive pricing and elimination of flat per-acre rates for water would only be required in some areas. This discussion is inconsistent with the mandate that incentive pricing be implemented as found in the prior documents IID recently commented upon. If incentive pricing and elimination of flat per-acre water rates are only to be implemented in some areas, this would be consistent with IID's view that such measures should only be implemented when deemed necessary and appropriate by the districts. IID has included more detailed comments about the Bureau of Reclamation's desire to mandate incentive pricing and elimination of flat per-acre water rates in its prior comment letters.

I hope the foregoing is helpful. If I can be of any further assistance, please do not hesitate to contact me at (619) 339-0650.

Respectfully submitted,

IMPERIAL IRRIGATION DISTRICT

By: [signature]
John Penn Carter
Chief Counsel

JPC\li

cc: Board of Directors
Michael J. Clinton
Robert A. McCullough
Jesse P. Silva

Attachments

3006-2028

TELEPHONE (619) 339-0646

IMPERIAL IRRIGATION DISTRICT

EXECUTIVE OFFICE • 1284 MAIN STREET • ~~P.O. BOX 1609~~ • EL CENTRO, CALIFORNIA 92244

May 24, 1995

Westside Settlement Manager
Bureau of Reclamation
Mail Code D-5010
P.O. Box 25007
Denver, Colorado 80225

RE: Comments to 43 CFR Parts 426 and 427
Acreage Limitation and Water Conservation Rules and Regulations

To Whom it May Concern:

Thank you for the opportunity to comment on the Bureau of Reclamation's Acreage Limitation and Water Conservation Rules and Regulations, proposed to be published as Parts 426 and 427 of Title 43 of the Code of Federal Regulations. This letter includes comments in addition to those comments submitted by Jesse P. Silva, Manager, Water Department, in a separate letter to you dated May 9, 1995.

Imperial Irrigation District (IID) recently commented on the Bureau's Draft Water Conservation Guidelines and Criteria in a letter to Commissioner Daniel P. Beard dated April 5, 1995. Attached is a copy of that letter to be incorporated within IID's comments on 43 C.F.R. Parts 426 and 427, as if fully set forth herein.

Additionally, we agree with the letters submitted on behalf of the Twin Falls Canal Company, Northside Canal Company, and Milner Irrigation District dated April 10, 1995 which related to the Draft Water Conservation Guidelines and Criteria, and would like to include the following comments.

IID believes that the Bureau of Reclamation should undertake and pay for any necessary compliance with the National Environmental Protection Act(NEPA). The activity undertaken in this case was initiated by the Bureau of Reclamation. Individual districts are not seeking approval of applications or permission to conduct activities and would therefore not be appropriate parties to pay for or conduct NEPA compliance.

IID also believes allocation of the Bureau's discretionary benefits should not be tied to the Water Conservation Guidelines and Criteria. We believe that, based on the experience of districts in the Central Valley Project, there is little certainty in the process of having conservation plans approved. Therefore, tying the approval of same to the allocation of discretionary benefits is not just or equitable.

Thank you again for the opportunity to comment on the Acreage Limitation and Water Conservation Rules and Regulations. Please call me at (619) 339-0650, if we can be of any further assistance.

Respectfully submitted,

IMPERIAL IRRIGATION DISTRICT

By: [signature]
John Penn Carter
Chief Counsel

JPC/li
3006-2028

Copies: IID Board of Directors
Michael J. Clinton
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Jesse P. Silva

Attachment

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IMPERIAL IRRIGATION DISTRICT

EXECUTIVE OFFICE • 1284 MAIN STREET • ~~P.O. BOX 1899~~ • EL CENTRO, CALIFORNIA 92244

April 5, 1995

Daniel P. Beard
Commissioner
Bureau of Reclamation
1849 C Street, NW
Room 7654
Washington, D.C. 20240

Re: Guidelines and Criteria for Water Conservation Plans (January 10, 1995)

Dear Commissioner Beard:

As Chief Counsel to Imperial Irrigation District ("IID"), I am authorized to submit the following comments on the Bureau of Reclamation's January 10, 1995 "Guidelines and Criteria for Water Conservation Plans" (the "Guidelines").

The current draft of the Guidelines raises a number of important policy and legal issues and, as a result, the following discussion is not confined to the specific language of the Guidelines. While our threshold comments extend beyond the scope of specific matters addressed in the Guidelines, we nevertheless submit them because of their paramount importance in the field of water conservation and federal regulation of the Colorado River. We would be pleased to discuss with Reclamation any of these matters at your convenience.

Like many western water users, IID appreciates Reclamation's commitment, as expressed in the introduction to the Guidelines, to meeting the "challenge of improving the efficiency of water use and management throughout the Western States" by forming partnerships between "Reclamation and water users, other Federal agencies, state agencies, educational and research institutions, and other interested parties."[1] In addition, we share Reclamation's view that the review of "existing water management practices" and conservation plans can result in "[i]mprovements in water

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1 Guidelines, p. 1.

management on Federal projects [which] can reduce overall operating costs, improve reliability of existing water supplies, postpone the need for new or expanded water supplies, and reduce the impacts of droughts." We hope that our comments and, where important enough to express, our concerns meet with your expectations, for we make them with the shared desire to promote and achieve the efficient allocation and use of the waters of the Western States.

Before addressing our specific comments on the Guidelines in Part IV of the following discussion, we discuss three threshold matters that place the Guidelines in a proper regulatory and policy context in Parts I, II and III, below.

I. MARKETS ARE THE OPTIMUM MEANS TO WATER CONSERVATION.

First and foremost, IID believes that water markets are the most effective means of achieving cost-effective conservation. The Guidelines emphasize that the economic benefits of water conservation do and should inure to water rights holders.[2] The Guidelines also recognize at several points the valuable role that water markets can play in encouraging conservation. The

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[2] California Water Code Section 1012 provides, in pertinent part, as follows:

> Notwithstanding any other provision of law, where any person, public agency or agency of the United States undertakes any water conservation effort, either separately or jointly with others entitled to delivery of water from the Colorado River under contracts with the United States, which results in reduced use of Colorado River water within the Imperial Irrigation District, no forfeiture, diminution, or impairment of the right to use the water conserved shall occur, except as set forth in the agreements between the parties and the United States.

See, also, Water Code Section 1011 ("no forfeiture of the appropriative right to ... water conserved shall occur upon the lapse of the forfeiture period applicable to water appropriated ... prior to December 19, 1914.")

Guidelines, however, could provide far stronger support for water conservation by including:

- Explicit recognition of the central importance that water markets play in achieving conservation; and
- Assurances that Reclamation will facilitate water transfers by its contracting agencies and not impede water markets by unnecessary regulation.

IID's view of water markets has developed based on necessity and experience. As IID adapts to the shift in federal water policy to economic conservation, it has found that water markets can and do play a valuable and, based on experience, crucial role in making water available to supplant uncertain supplies and meet dynamic demands, within and without discrete geographic regions. Optimal water conservation efforts will depend on the development of water markets in an economic environment free of excessive regulation. The development of *economically efficient* markets will depend on the adaptation of federal and state water policy. Thus, IID's view of water policy has emerged to embrace the principle that optimum water management includes conservation by districts and farmers and the nurturing of water markets. Undue regulation will create uncertainty, stifle competition, breed unnecessary conflict, compound transaction costs and, in the end, undermine prudent, timely and efficient water conservation and transfers.

II. CONSERVATION GOALS SHOULD COMPORT WITH STATE LAW.

Meaningful comment on federal guidelines and criteria for conserving water under state law based water rights needs to address the omnipresent jurisdictional issue of federalism. Some portions of the Guidelines could be read as displacing traditional deference to state law. As a policy matter, the Guidelines should and, in accordance with recent holdings of the United States Supreme Court, must demonstrate due deference to state law, particularly where, as here, the content and character of a district's water rights are grounded in state law.

Specifically, IID is concerned that the Guidelines contravene traditional and, under *California v. United States*, 438 U.S. 645 (1978), contemporary notions of federalism. IID believes that the Secretary is overstepping his power by regulating the use of Colorado River water -- particularly water distributed in satisfaction of present perfected rights -- without an express and specific directive by Congress. In this regard, IID recognizes that Congress may choose to expand the Secretary's plenary power under Section 5 of the Boulder Canyon Project Act to contract for the distribution of Colorado River water by conferring upon the Secretary the power to regulate the use of irrigation water within the boundaries of the individual Lower Basin States. Congress, however, has consciously and steadfastly refused to embark on a wholesale restructuring of the fundamental principles of federalism that have governed reclamation law since the passage of Section 8 of the Reclamation Act of 1902 (which did not affect, and directs the Secretary to proceed in conformity with, state laws relating to the "control, appropriation, use, or distribution" of irrigation water). And while the power of the states to control the use and distribution of irrigation water from federal reclamation projects has led a tortured and, at times, revisionist history[3] the most recent opinions by the United States Supreme Court on the relationship between federal and state power overruled the Court's prior departures from the strictures of Section 8 of the Reclamation Act of 1902.[4]

Moreover, the enactment of Section 210 of the Reclamation Reform Act of 1982 ("RRA") is not an express Congressional directive for the Secretary to impose, let alone enforce, the Guidelines. The language of Section 210(a) makes clear that Congress did not expand then existing federal reclamation law governing the use of irrigation water from a federal project:

> The Secretary shall, *pursuant to his authorities under otherwise existing Federal reclamation law*, encourage the full consideration and incorporation of prudent and responsible water conservation measures in the operations

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[3] *See, e.g.*, *Ivanhoe Irrigation District v. McCracken*, 357 U.S. 275 (1958), *City of Fresno v. California*, 372 U.S. 627 (1963), and *Arizona v. California*, 373 U.S. 546 (1963).

[4] *California v. United States*, 438 U.S. 645, 668-69 n.21, 672-75 (1978) (the states have a right to control the waters from federal reclamation projects to the extent not inconsistent with specific congressional directives), and *Bryant v. Yellen*, 447 U.S. 352, 371 (1980) (state law was not displaced by the Boulder Canyon Project Act and "must be consulted in determining the content and characteristics of the water right that was adjudicated to [IID]."

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> of non-Federal recipients of irrigation water from Federal reclamation project.

RRA §210(a), 43 U.S.C. §390jj (emphasis added). In promulgating regulations implementing Section 210, the Secretary has been notably deferential to the discretion of a district to devise and implement a conservation plan. The genesis of this deference lies with the limited authority Congress conferred on the Secretary. By authorizing the Secretary to "encourage" water users to undertake water conservation plans, Congress by no means conferred upon the Secretary a directive to occupy the field of water conservation. Indeed, three of the Secretary's responses to certain comments on the first draft of the regulations implementing Section 210 of the RRA recognize the limited authority conferred by Congress.

First, the Secretary responded to several comments about the generality and vagueness of the first draft of the regulations for water conservation measures by noting the limited power conferred by Congress:

> The water conservation provisions of these rules are ... general by intent since it is the districts which will develop and carry out the water conservation programs. However, the rule does emphasize that the Secretary of the Interior will encourage water conservation initiatives by districts, *recognizing that the responsibility for these efforts is primarily that of the districts*, not that of the Federal Government. This is in accord with the intent expressed by Congress in the water conservation provision in the RRA.

43 C.F.R. Part 26, December 6, 1983 (response to comment 1 on Section 426.19(a)) (emphasis added).

Second, in response to a written comment that any guidelines developed by the Secretary would "become requirements for the districts," the Secretary disavowed any such mandate:

> The rules do not indicate that the Bureau of Reclamation will dictate the provisions of water conservation plans, nor does the Bureau of Reclamation intend to impose requirements of this nature on districts.

43 C.F.R. Part 26, December 6, 1983 (response to comment 1 on Section 426.19(b)).

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Third, the Secretary rejected entreaties to promulgate more comprehensive water conservation criteria with the following:

> We believe the broad provision for water conservation planning efforts by districts, as expressed in the rules, is preferable to attempting to provide comprehensive criteria for these efforts. The districts will be required to develop the plan and will have the primary responsibility for its implementation. The resources that will be devoted to this effort will vary greatly depending upon district need and *economic capability*. The water conservation guidelines which are being developed by the Bureau of Reclamation will identify the objectives and goals that should be considered in the planning effort, as well as the review procedure a district may wish to incorporate into its plan.

43 C.F.R. Part 26, December 6, 1983 (response to comment 2 on Section 426.19(b)) (emphasis added).

Finally, nothing in the second or third (and final) draft of the regulations[5] supports, or even suggests, a basis for the Secretary to now disavow his limited authority to control the use of water from federal reclamation projects. Consequently, the Secretary should subscribe to the application of state law and seek voluntary district compliance with the Guidelines. The Secretary cannot and should not mandate that certain water conservation measures be adopted by any district. As discussed below, certain mandates may not be operationally practical or economically feasible for a particular district. In addition, the Secretary should not withhold "discretionary benefits" or impose other penalties absent voluntary compliance. Many of the discretionary benefits that are available to the districts are themselves worthy objectives and goals for a conservation plan. For example, the Secretary should not refuse to facilitate water transfers for a district or refuse to aid in the funding of a district's conservation activities as a penalty for the absence of an acceptable conservation plan or for the late development of a conservation plan when transfers are commonly viewed as the ultimate conservation measure. This does not comport with the

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[5] *See* 43 C.F.R. §426.19, November 7, 1986 and April 13, 1987.

Secretary's limited power under Section 210 of the Reclamation Reform Act or good reclamation policy.

Notwithstanding these concerns over the Secretary's authority to regulate areas traditionally reserved to the states, IID is encouraged that the Guidelines contemplate Reclamation's acceptance of a conservation plan prepared for a state agency, as well as its willingness to work with water users to determine which alternative requirements under a state plan will meet, in whole or in part, the requirements of a Reclamation-approved conservation plan. However, the Guidelines do not express what role, if any, traditional federal deference to state law will play in Reclamation's "case-by-case" adjustments to the requirements for Reclamation-approved water conservation plans. Since the RRA did not expand the Secretary's authority, IID recommends that Reclamation follow existing federal law by deferring to state law. As a consequence, Reclamation should presumptively accept state-approved conservation plans.

Similarly, and as discussed more extensively below, the Guidelines include criteria and requirements that do not recognize state law governing the pricing of water service provided by public agencies and other legal obligations of local agencies. Since neither Reclamation law generally nor the RRA specifically preempts these features of state law, adoption of the Guidelines in their current form runs the needless risk of litigation to establish, once again, federal deference to state law in the area of the use of water resources.

Even though IID's comments on the Guidelines in Part IV presume that the Secretary enjoys a limited role, IID nevertheless believes that the Guidelines can provide valuable direction to water districts in their efforts to manage their resources prudently and should encourage water districts and water users to achieve economically feasible water conservation. In that regard, IID commends many of the current themes contained in the Guidelines, including the importance of working cooperatively with state and local agencies, the critical role of water markets in promoting conservation, and the authority of local users to determine how conserved water should be used.

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III. GUIDELINES SHOULD ENCOURAGE ECONOMICALLY FEASIBLE CONSERVATION.

Subject to IID's threshold concerns about the interaction of the Guidelines with the development of water markets and the role of state law, IID believes that, with the modifications and suitable clarification of select issues posed by the Guidelines, the Guidelines can provide a framework for the management of western water resources in a manner consistent with the applicable federal and state law.

1. Statutory Framework.

Section 210(a) of the RRA, of course, provides the statutory framework for Reclamation's Guidelines. Section 210(a) directs the Secretary to:

> Encourage the full consideration and incorporation of prudent and responsible water conservation measures in the operations of non-Federal recipients of irrigation water from Federal reclamation projects, where such measures are shown to be *economically feasible* for such non-Federal recipients.

RRA §210(a), 43 U.S.C. §390jj (emphasis added). To this end, Section 210(b) requires districts that have entered into repayment or water service contracts with Reclamation pursuant to Federal reclamation law or the Water Supply Act of 1958 to:

> Develop a water conservation plan which shall contain definite goals, *appropriate* water conservation measures, and a time schedule for meeting the water conservation objectives.

RRA §210(b), 43 U.S.C. §390jj (emphasis added). Synthesizing the main elements of the framework of Section 210 reveals that *appropriate* water conservation measures include those, and only those, measures that are *economically feasible*. The Guidelines, however, fail to adhere to these limits relative to the Secretary's power to encourage districts to undertake conservation measures.

2. Overriding Principles.

Reclamation law generally, the RRA specifically, and sound public policy each dictate that the Guidelines comply with three overriding principles:

> (1) Water conservation efforts must be measured by an economic "cost-benefit test" as the means to determine economic feasibility;
>
> (2) Economic incentives provide the most effective and reliable way to implement economically-feasible water conservation actions; and
>
> (3) The review of water conservation plans must use, when feasible, objective criteria based on professionally-recognized quantification methods.

For reasons discussed below, the Guidelines do not always conform with these principles.

<u>Economic Feasibility</u>

As already discussed, the statutory framework for water conservation plans is based on the economic feasibility of water conservation actions for water users. Regrettably, the Guidelines make no mention of economic feasibility. Instead, the Guidelines include "financial feasibility" as one of many factors to be considered in assessing water conservation measures. For two reasons, this approach does not conform with the statutory framework for Reclamation-approved water conservation plans.

First, financial feasibility is not the same as economic feasibility. Financial feasibility commonly considers whether a water agency, for example, has the financial resources to undertake a specific action. As such, financial feasibility does not assess whether the contemplated action is a wise use of resources. In contrast, economic feasibility considers whether the economic benefits of a specific action exceed the economic costs. Consistent with this principle, the Guidelines make clear that "water conservation is not an end in itself."[5] IID applauds the inclusion of this statement in the Guidelines. IID suggests that the substantive provisions of the Guidelines comply with this fundamental statutory and economic principle.

Second, even if Reclamation means economic feasibility when it uses the term "financial feasibility," the Guidelines are, at best, unclear in whether they implement the statutory framework adopted by Congress. Section 210(a) requires conservation plans to include economically feasible conservation measures -- no other factors are enumerated. Consequently, the role of many of the other factors enumerated in the Guidelines (*e.g.*, efficiency of water delivery and use, quantity of water to be saved, and technical feasibility) are properly subsumed as part of the elements of a comprehensive economic application of a "cost-benefit" test. Such factors should not be put on an equal footing with the paramount statutory criterion of economic feasibility.

Economic Incentives

Effective and reliable implementation of conservation actions must be based on economic incentives. When water conservation actions generate net benefits for water users and districts, affected parties naturally become a constituency for implementation. When they do not benefit from contemplated actions, the result will be political and legal controversy, less actual "wet" conserved water and the uncertainty of the development of workable markets. As discussed more extensively below, many of the specific provisions in the Guidelines seem to rely on forced conservation actions rather than economic incentives.

IID recommends that Reclamation adopt an explicit statement emphasizing the critical role for economic incentives contemplated by the Guidelines. For the legal and public policy reasons discussed above, the draft Guidelines should provide that economic incentives are the favored means of achieving conservation goals. The Guidelines also should clarify that a district need not impose additional conservation measures on its users if it has effective economic incentives in place.

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[5] Guidelines, p. 19.

Objective Standards

The Guidelines require water users to undertake a comprehensive analysis of the consequences of a wide array of alternative conservation actions. Such an analysis would include many factors, including the potential amount of conserved water and the effects on water users and the environment. Given the wide variety of impacts to be estimated, it is inevitable that different estimation methods can yield materially different results. The Guidelines provide no indication about how Reclamation will address the inevitable controversies that will arise when different parties employ different methods.

The Guidelines could be improved considerably by including language that Reclamation's review of water conservation plans will be based on professionally-recognized quantification methods. Given the widely-recognized importance of site-specific conditions and the diversity of circumstances of local water systems and the local environment throughout the West, it may prove impossible for Reclamation to enumerate comprehensively which professionally-recognized methods should be used in which circumstances. At the same time, to assure water users that their conservation planning efforts do not become a victim of perpetual second-guessing, Reclamation should state a policy of either (1) letting water users determine which professionally-recognized methods of quantification are most appropriate for their circumstances, or (2) discussing with water users (*before* a water conservation plan is prepared) which professionally-recognized quantification methods Reclamation finds acceptable.

IV. SPECIFIC COMMENTS ON GUIDELINES.

In addition to the foregoing concerns, IID offers the following specific comments to the Guidelines:

1. Critical v. Additional Water Conservation Measures.

IID finds the category "critical water conservation measures" inconsistent with relevant federal statutory provisions. The Guidelines imply that *all* of the measures specified as "critical" *must* be implemented within designated time schedules. That is, each of these conservation measures is an "end in itself." Based on Section 210, IID suggests that all *economically feasible* measures be adopted within appropriate time schedules as dictated by the marketplace.

Re: Guidelines and Criteria for Water Conservation Plans (January 10, 1995)

To illustrate IID's concern, the Guidelines include as a critical water conservation measure the installation of measurement and accounting systems that can meter or measure the volume of water conveyed to individual water users, "metered or measured at each agricultural turnout and/or service connection." Suppose, for example, this language was interpreted to *require* IID to install meters at the more than 5,000 points of delivery within the district. Rather than assume that such actions are economically feasible, the Guidelines should only request that such a program be analyzed to determine whether it is, in fact, economically feasible.

In principle, a comparable concern could also be raised about the critical water conservation measures related to reform of any water pricing based on declining unit price or flat rate per acre or household regardless of the quantity used. IID water service charges are already based on the amount of water delivered thereby giving farmers incentives to save water. Any further reforms required by the Guidelines, therefore, would have no practical effect on IID, and could misidentify certain farming uses as excessive given IID's multiple cropping seasons. Nonetheless, IID finds that the mandatory nature of *any* "critical water conservation measure" conflicts with the scheme of water conservation planning specified by federal law.

A more appropriate formulation for water conservation measures would be for the Guidelines to:

- List the candidate actions that all water users, whether agricultural or municipal/industrial users, should consider;

- List additional candidate actions specifically for agricultural water users and those specifically for municipal/industrial users; and

- Not mandate any candidate actions, but let the districts analyze and, if economically feasible, adopt in their conservation plans certain of the candidate actions.

An advantage of this approach is that it follows the express language of the RRA.

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2. Economic Feasibility of Conservation Plans.

As discussed earlier, the economic feasibility of a conservation measure is the critical factor in determining whether a district should pursue the measure. Even if a conservation measure is economically feasible, moreover, good public policy might dictate that a district not pursue the measure. For example, an alternative measure might be able to achieve the same result at lower overall cost or with less disruption to legitimate economic expectations or investments.

To reflect these points, the last paragraph on page 21 and the first two paragraphs on page 22 of the Guidelines should be revised to read as follows (modifications appear in italics):

> All water conservation measures so identified should be analyzed and evaluated to determine whether it is *economically* feasible for a district to implement them, either individually or in various combinations. *This determination should consider both the actual economic value of the conserved water and the costs of conservation to all parties, including both the districts and water users.* The district may consider the costs of environmental compliance associated with implementing each proposed water conservation measure in combination with all other costs associated with the measure in determining the feasibility to the district of the measure's implementation.
>
> *If a water conservation measure is determined to be economically feasible, then the measure should also be analyzed and evaluated from the standpoint of other relevant factors including the opportunities for achieving the same conservation through other less costly means, any negative environmental impacts, and disruption to economic expectations and investments. If a district determines that a measure is economically infeasible, that an alternative measure can achieve the same goal at lower costs or impact, or that the drawbacks of a measure outweigh its*

advantages, then the basis and rationale for that determination should be documented in the water conservation plan.

3. Economic Value of Conserved Water.

The economic value of conserved water is a critical factor in the analysis of economic feasibility of any conservation action. The Guidelines provide, at best, incomplete guidance and notice on the nature of the analysis Reclamation will find acceptable. IID is especially concerned about the economic valuation of conserved water for uses outside a district.

IID recommends that any economic valuations of conserved water used outside a district must be based on consummated comparable market transactions and, in the absence of such transactions, bona fide offers with respect to prospective comparable transactions. The current language in the Guidelines raises the prospect that Reclamation may require that the value of conserved water be based on *estimates* of the possible value of water in other uses. As a trustee for the equitable and beneficial interest of landowners' in the district's water supply, IID can only conserve water for transfer outside the district in response to real, credible and comparable transfer opportunities, not hypothetical or phantom transfer opportunities.

The risk of overstating the economic benefit of a conservation measure is real. Consider, for example, the State of California's experience with the first year of the Drought Water Bank. At the height of the seven-year drought in 1991, the Department of Water Resources contracted to purchase over 820,000 acre-feet of water, more than one-half of which was "developed" by fallowing farmland. Water was purchased at $125 per acre-foot and sold for $170 to $175 per acre-foot. While the Department of Water Resources expected demands to exceed supplies, in reality the converse occurred. Over 260,000 acre-feet of water was not purchased in 1991 and carried over to the 1992 Drought Water Bank.

Based on this example, too many farmers undertook excessive conservation measures (by fallowing farmland), which the short-term needs for additional water supplies did not economically justify. Experience with the Drought Water Bank indicates that the purchase price of water -- which was determined without the benefits of the marketplace -- was too high in 1991. Indeed, the 1992 Drought Water Bank reflected a significant reduction in the purchase price of water, from $125 to $50 per acre-foot, with a commensurate reduction in the sales price, from $175 to $72 per acre-foot. This experience clearly teaches that an analysis of the economic feasibility of water conservation measures should not be based on hypothetical or phantom transfer opportunities. An analysis of the economic feasibility of conservation measures must be based on an actual, consummated comparable transaction or, in appropriate circumstances, bona fide offers.

4. Local Control of Conserved Water.

IID supports the language in the Guidelines recognizing that the use of conserved water is "a decision left to each district". This approach represents sound public policy and, at least for water users in California, conforms with state law. IID recommends that the Guidelines extend its discussion on local control of conserved water. The discussion could note the importance of market-based economic incentives for implementation of water conservation actions. To this end, the discussion could also make more explicit the prominent role for voluntary transfers as the most important conservation measure. In addition, it is important that districts have the use of project facilities to transport and store conserved water. Accordingly, Reclamation should formally waive the requirements for a Warren Act contract as they relate to the use of project facilities to manage conserved water.

5. Incentives for Approved Plans.

The Guidelines include language suggesting that Reclamation may withhold approval of water transfers if participants do not have a prior-approved water conservation plan. We question this policy. If the Guidelines were implemented in their present form, the purpose of the Guidelines would be subverted. Water transfers are perhaps the most practical and effective way to implement economically feasible water conservation actions. Reclamation should not foreclose the opportunity of water users to pursue water marketing opportunities as a *means* to achieve water conservation.

6. Incentive Pricing.

IID has three concerns about the Guidelines' discussion of incentive pricing:

- Incentive pricing poses potential conflicts with IID's obligations as a fiduciary to its landowners under state law;

- The incentive pricing provision reflects a goal of "conservation as an end in and of itself,"; and

- Reclamation lacks authority to impose any specific pricing scheme.

First, California law specifies that IID has fiduciary obligations to protect and promote landowners' equitable and beneficial interest in the district's water supply. It also has an obligation to provide reliable water service at reasonable rates. As a consequence, any incentive pricing scheme must comply with IID's obligations under state law. Therefore, IID recommends that the draft Guidelines' discussion of incentive pricing as a potential additional water conservation measure for agricultural users expressly recognize that *all* pricing schemes shall comply with applicable state law. To this end, the provision should read:

> (a) Incentive Pricing - implement any lawful increasing tiered block water pricing structure or other lawful water pricing structure, that results in economically feasible water conservation.

Second, the Guidelines' discussion of incentive pricing does not relate pricing to any specific policy objective. Instead, the impression is given that pricing should be "reformed" simply as a means to conserve water. All economists agree that prices affect the allocation of resources, and prices can be raised to the point where demand for the resources will wane and eventually disappear. But this would be the point where farmers stop farming. Is this the desired end? For whose benefit? In other words, should water be conserved by any means, regardless of the fiduciary duty of districts and the disruption of expectations and investments of landowners and water users? For reasons discussed above, existing law and public policy dictate that water conservation should occur only when it is economically feasible and implemented by economic incentives.

Third, Reclamation lacks the legal authority to impose the incentive pricing scheme. IID finds the Guidelines' lack of any discussion on this critical point to be an admission of the absence of Secretarial authority to impose pricing structures on districts.

7. Land Management.

Similarly, the Guidelines should recognize that water agencies have little, if any, statutory powers to manage land use. Moreover, the Secretary lacks legal authority to address land use issues. Like the case of incentive pricing, there is no evidence that Congress authorized the Secretary to address these issues. As a consequence, the additional water conservation practice for agricultural water users captioned, "(f) Land management," should be dropped entirely.

8. Environmental Review.

The Guidelines provide insufficient guidance on the scope and comprehensiveness of the environmental assessment Reclamation will require for acceptable water conservation plans. Should IID prepare the equivalent of a programmatic environmental impact statement, project environmental impact report, or an environmental assessment? Should IID consider the environmental consequences of conservation measures that are found to be economically infeasible *before* any consideration of any potential cost of compliance with applicable state and federal environmental law? Without the answers to these and comparable questions, IID fears that the Guidelines provide insufficient practical guidance to prepare a water conservation plan that Reclamation would find acceptable.

Especially in conjunction with the above concerns, IID finds the initial 15-month period for the preparation of such plans troublesome considering the size, scope, and diversity of collateral issues related to water use in IID's service area and the source of IID's water supply. Concerning any environmental review related to the Colorado River, to what extent should IID's review conform with the reviews conducted by other users of Colorado River water? While the Guidelines encourage water users to cooperate in the preparation of their water conservation plans, IID does not believe that preparation of a joint plan will prove to be simple. For example, only a portion of the environmental issues facing IID conservation actions will be suitable for inclusion in a joint plan.

In light of these considerations, IID recommends that Reclamation change the Guidelines as follows:

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- Restrict the needed environmental review to water conservation actions found to be economically feasible *before* any consideration of any potential cost of compliance with applicable state and federal environmental laws;

- Require environmental review of only the water conservation actions that a district considers to actually undertake, rather than all of the possible actions a district may undertake; and

- Limit the environmental review to an environmental assessment and require further environmental review only if market conditions justify implementation of a conservation plan or portions thereof.

9. **Exemptions.**

Small contractors should not be exempted from requirements to prepare water conservation plans. However, it may be appropriate to require small contractors to submit plans which comply with relaxed requirements. Additionally, by requiring small contractors to submit water conservation plans, Reclamation would not face potential liability for treating contractors unequally by requiring some to submit plans and exempting others.

Mid-sized entitlement holders should be required to comply with the same requirements for water conservation plans as all other entitlement holders. If relaxed standards are applied to any size entitlement holders, they should be applied only to small contractors, as defined in the Guidelines. The cumulative effects of possibly applying less stringent conservation plans to mid-sized and small contractors are potentially enormous. Focusing conservation requirements primarily on large contractors is unduly discriminatory.

Finally, Indian Federal entitlement holders should be required to develop and submit water conservation plans. There is no legal authority for treating these entitlement holders differently than any other entitlement holder with regard to the application of the Guidelines.

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10. Relation to 43 C.F.R. Part 417.

Water Conservation plans should not be required in addition to the requirements of 43 C.F.R. Part 417. Instead, water users subject to Part 417 should be exempt from the application of the Guidelines.

We hope the foregoing is helpful. Please call me if we can be of further assistance.

Respectfully submitted,

IMPERIAL IRRIGATION DISTRICT

By [signature]
John P. Carter
Chief Counsel

JPC:teri
3006-2014

Copies: See attached list.

Copies List:

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United States Department of the Interior

TAKE PRIDE IN AMERICA

BUREAU OF RECLAMATION
LOWER COLORADO REGIONAL OFFICE
P.O. BOX 427
BOULDER CITY, NEVADA 89005

IN REPLY REFER TO: LC-470

JUL 29 1987

Mr. Charles L. Shreves
General Manager
Imperial Irrigation District
P.O. Box 937
Imperial, California 92251

Dear Mr. Shreves:

Enclosed is a letter, dated June 25, 1987, from the Commissioner of the Bureau of Reclamation, reaffirming our commitment for improvement of water management and conservation practices in the West. We believe that the development and implementation of a practical water conservation plan (WCP), such as the the one your organization has submitted, will play a role in assisting the West to meet its increasing water demands now and in the future.

We thank you and your organization for the cooperation and effort you have shown in the preparation of your WCP. We look forward to working with you in a continuing effort to utilize our water resource efficiently and effectively.

Sincerely yours,

ACTING FOR David T. Geibel

Edward M. Hallenbeck
Regional Director

Enclosure

8-10-87/sg
Copy: Wheeler

United States Department of the Interior

BUREAU OF RECLAMATION
WASHINGTON, D.C. 20240

IN REPLY REFER TO: 430

June 25, 1987

To: All Reclamation Project Water User Organizations

In 1985, our Regional Office informed you about the water conservation plans required under section 210 of the Reclamation Reform Act of 1982 and furnished you a copy of our "Guidelines for Development of Irrigation Water Conservation Plans," dated December 1984. A deadline of July 1, 1987, was established for submission of the conservation plans. Most irrigation districts have already responded and, undoubtedly, others have plans in the final stages of development since the deadline is near.

I want to reaffirm the Bureau of Reclamation's commitment to improvement of water management and conservation practices in the West. As you are aware, there are increasing demands being placed on the water systems we have developed. It is essential that these demands be met while future capital investment costs are effectively controlled. To this end, I encourage you to continue your efforts in water conservation by implementing your water conservation plans as soon as practicable.

The Regional Director and his staff are available to answer any questions you may have regarding the water conservation plans. Should you need assistance, please feel free to call them.

Sincerely yours,

Terry L. Lynott
for C. Dale Duvall
Commissioner

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Shreves/gar/339-9220

IIDGM

June 24, 1985

Mr. Vernon E. Valantine
Chief Engineer
Colorado River Board
107 S. Broadway, Room 8103
Los Angeles, CA 90012

Dear Vernon:

This is in response to your letter dated June 17, 1985, concerning the draft "California's Stake in the Colorado River."

The recommended modifications on the second page more closely represent the proposed Memorandum of Understanding that is currently being negotiated between MWD and IID.

Sincerely,

Charles L Shreves

CHARLES L. SHREVES
General Manager

Attachments
VALANTINE

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Maximizing California's Use of Its Basic Colorado River Apportionment

In order to minimize the impacts from being limited to their basic apportionment of 4.4 million acre-feet a year, the California agencies and the Colorado River Board are investigating measures that could maximize the beneficial use of the apportionment. One of these measures is the possible lining of the All-American Canal. The Bureau of Reclamation has made a preliminary estimate that 87,000 acre-feet a year could be conserved by reconstructing a 30-mile portion of the canal. The Board has assisted in obtaining Congressional authorization for a feasibility study of the reconstruction. Following lining, ground water along the canal could be recovered from the East Mesa area of Imperial County by installing a number of wells. Staff guidance has also been provided in the performance of a study by a private engineering firm in assessing the feasibility of recovering this accumulated seepage that has resulted from All-American Canal and Coachella Canal leakage since the 1940's.

Another measure under investigation is the lining of selected canals and laterals within the Imperial Irrigation District to reduce water losses by leakage and making other improvements in the water distribution systems in Imperial Irrigation District and [Coachella Valley Water District]? that would reduce water lost to the Salton Sea. The Board's staff has worked with the Bureau of Reclamation on reconnaissance-level studies of Imperial Irrigation District [and Coachella Valley Water District]? water conservation opportunities. The Metropolitan Water

District and Imperial Irrigation District are working on a cooperative water conservation program in which Metropolitan would ~~pay for water conservation measures and use the water made available~~ MAKE ANNUAL PAYMENTS INTO THE IID WATER CONSERVATION FUND, FOR WHICH THEY WOULD RECEIVE THE RIGHT TO TAKE A FIXED AMOUNT OF CONSERVED WATER.

Other measures include utilizing unused agricultural priority water in certain years and making full use of unused water allocations of the Indian Reservations. The Board's staff is developing a method to forecast agricultural water use. With such a method, the Metropolitan Water District could then plan its operations so as to use the projected unused water in the last few months of years that it becomes available.

Finally, operational criteria are being developed in cooperation with the Department of the Interior that would permit flexibility by Arizona and California agencies in the utilization of their Colorado River entitlements from year to year. Many of these prospects are long-term in nature and will require agreements among agencies and expenditure of funds for construction of facilities.

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PUBLIC INFORMATION CLIP SHEET
IMPERIAL IRRIGATION DISTRICT

PUBLICATION INDIO DAILY NEWS

DATE JANUARY 28, 1985

SECTION/PAGE Page- 8

Surface irrigation makes comeback

FRESNO (AP) — Surface irrigation, downgraded in recent years as drip and sprinkler systems were touted for water conservation, may be making a comeback.

Agriculture absorbs 85 percent of all water used in California, and surface or flood systems are used on 80 percent of the 5.5 million acres that are irrigated, said Joseph B. Fiala, sales vice president of Waterman Industries. Fiala called for farmers to practice "wise stewardship of our water" so the state's "cornucopia" of food can continue.

"Obviously, the onus is on surface irrigation to clean up its act," Fiala said during a seminar at the AgFresno farm equipment show. "It's water spilling off the ends of furrows that makes waste so visible and agriculture so vulnerable."

But Fiala, whose company makes irrigation equipment, said he sees a "renewed acceptance of surface irrigation" because of "dramatic improvements" in technology.

"Research studies and papers reaffirm that this method can offer efficiencies that run well into the 80 and 90 percent range," he said. "The kicker is that they must be properly designed and properly managed."

Fiala cited these examples of ways improved technology make surface irrigation less wasteful:

--Improved information on when to best schedule irrigation is available from University of California Extension or commercial companies.

--Irrigation system designs have improved markedly, showing "greater sophistication and added expertise."

Such changes include surge irrigation, in which pumps and timers provide periods when no water is flowing in between periods of full flow.

--There is increased efficiency in applications such as "dramatic gains through laser leveling."

In addition, attitudes have changed so that "the ethic of reuse is alongside the ethic of less use," Fiala noted.

The importance of these attempts to use water more efficiently goes beyond just saving the water itself, he said.

"Wasted water causes other problems. It also washes away fertilizer," Fiala said. "Wasted water is the highest cost in farming. It adds nothing to yield and brings zero dollars income."

He contended that because of improved technology, surface irrigation may remain the most practical irrigation method for most farmers.

"The highest irrigation efficiency and lowest energy costs and greatest gains in water conservation all are available with surface irrigation," Fiala said. "The technology is here today. Let's hope the farmer uses it."

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IMPERIAL IRRIGATION DISTRICT
DIVERSION REQUIRED AT DROP 1 FOR IMPERIAL UNIT

Double Cropping

Average 10 Years - 1973 - 1982	Acres		
Acres in Crops	582 500		
Net Area Irrigated	457 000		
Area Double Cropped 21.5% of 582 500 Acres	125 500	Say 22%	

Water Required for Delivery to Farms 1/

Average Consumptive Use 2/ 4.65 AF/A	2 125 000 AF	
Leaching Requirement 3/ (0.15 X 2 125 000/0.85)	375 000 AF	
Farm Efficiency 4/		85%
Water Conveyance Efficiency 5/ (System regulation and losses)		91%
Project Irrigation Efficiency 6/ (85% X 91%)		77%
Water Required at Drop #1 for Delivery to Farms with present efficiency $\frac{(2\ 125\ 000 + 375\ 000)}{0.77}$	3 246 500 AF	

If farm irrigation efficiency were to be increased from 85% to 90% in the future due to better management practices, and water conveyance efficiency were to be increased from 91% to 93% in the future due to Imperial Irrigation District's water conservation program, then: Future Project Irrigation Efficiency = 0.91 X 0.93 = 0.85 and Future Water Required at Drop #1 = $\frac{2\ 125\ 000 + 375\ 000}{0.85} = 2\ 941\ 000$ AF.

1/ For this and subsequest explanatory notes, see p. 1-A.

8/12/83 T-1112

Copy to R.F.C 9/21/83

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EXPLANATORY NOTES

1/ Water Required at Drop 1 = $\frac{\text{Consumptive Use + Leaching Requirement}}{\text{Project Irrigation Efficiency}}$

2/ Based on Kaddah, M. T. and Rhoades, J. D., 1976, Salt and Water Balance in Imperial Valley, California. Data in this work was based on lysimeter studies at the Imperial Valley Research Center and on Blaney-Criddle formula. Refer to pages 2 to 12 this report.

3/ Based on average salt tolerance for reasonable yield reduction. U.S.D.A. Handbook No. 60 and Bulletin 283. Also, refer to pages 13 to 23 this report.

4/ Farm Irrigation Efficiency = $\frac{\text{Water Delivered to Farm less Surface Runoff}}{\text{Water Delivered to Farm}} \times 100$

A farm irrigation efficiency of 85% was considered as a good one by the Imperial Conservation Research Center, Brawley, California. It was assumed that there was no loss due to deep percolation.

5/ Average Water Conveyance Efficiency from All-American Canal Drop 1 to farms. Refer to page 24 this report.

6/ Project Irrigation Efficiency - Farm Irrigation Efficiency X Water Conveyance Efficiency, Jenson, M., Swamer, L., Phelan J.; Improving Irrigation Efficiencies: Agronomy, Madison, Wisconsin, 1967, Section 13, Chapter 61, page 1120.

IMPERIAL IRRIGATION DISTRICT
Consumptive Use of Areas Cropped
1973

(Acres in Crop to Nearest 500 Acres)

	Acres	CONSUMPTIVE USE Ac. Ft. 1/ Per Ac.	CONSUMPTIVE USE Ac. Ft.
Alfalfa	176 000	6.0	1 056 000
Barley	17 500	*1.8	31 500
Cotton	37 000	3.6	133 000
Sorghum, Grain	39 500	2.5	99 000
Sudan	13 000	2.5	32 500
Sugar Beets	70 000	3.7	259 000
Wheat	94 500	2.1	198 500
Misc. Field Crops	26 000	*2.5	65 000
Melons	13 000	*2.3	30 000
Lettuce	41 000	1.4	57 500
Carrots	5 000	1.3	6 500
Tomatoes	2 500	2.3	6 000
Misc. Garden Crops	9 500	1.7	16 000
Citrus	2 500	3.8	9 500
Misc. Permanent Crops	14 000	4.2	59 000
Total	561 000	3.67	2 059 000

Net Acres Irrigated - 444 500

Consumptive Use per Net Acre Irrigated - 4.63

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, p. 93-100.

* Based on Blaney-Criddle formula.

PERIAL IRRIGATION DISTRICT
Consumptive Use of Areas Cropped
1974

(Acres in Crop to Nearest 500 Acres)

	Acres	CONSUMPTIVE USE Ac. Ft. 1/ Per Ac.	CONSUMPTIVE USE Ac. Ft.
Alfalfa	158 000	6.0	948 000
Barley	5 500	*1.8	10 000
Cotton	79 000	3.6	284 500
Sorghum, Grain	31 500	2.5	79 000
Sudan	14 500	2.5	36 500
Sugar Beets	69 000	3.7	255 500
Wheat	101 500	2.1	213 000
Misc. Field Crops	16 500	*2.5	41 500
Melons	11 000	*2.3	25 500
Lettuce	48 500	1.4	68 000
Carrots	6 500	1.3	8 500
Tomatoes	3 000	2.3	7 000
Misc. Garden Crops	12 500	1.7	21 500
Citrus	2 500	3.8	9 500
Misc. Permanent Crops	13 500	4.2	56 500
Total	573 000	3.60	2 064 500

Net Acres Irrigated - 450 000

Consumptive Use Per Acre Irrigated - 4.58

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, p. 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED
1975
(Acres in crop to nearest 500 acres)

	Acres	Consumptive Use 1/ Ac. Ft. per Ac.	Consumptive Use Ac. Ft.
Alfalfa	159 500	6.0	957 000
Barley	3 500	*1.8	6 500
Cotton	43 000	3.6	155 000
Sorghum, Grain	24 500	2.5	61 500
Sudan	13 000	2.5	32 500
Sugar Beets	71 500	3.7	264 500
Wheat	155 500	2.1	326 500
Misc. Field Crops	16 000	*2.5	40 000
Melons	11 500	*2.3	26 500
Lettuce	45 000	1.4	63 000
Carrots	6 000	1.3	8 000
Tomatoes	6 000	2.3	14 000
Misc. Garden Crops	15 000	1.7	25 500
Citrus	2 500	3.8	9 500
Misc. Permanent Crops	13 000	4.2	54 500
Total	585 000	3.49	2 044 500

Net acres irrigated 456 500

Consumptive use per net acre irrigated - 4.48

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED
1976
(Acres in crop to nearest 500 acres)

	Acres	Consumptive Use 1/ Ac. Ft. per Ac.	Ac. Ft.
Alfalfa	169 500	6.0	1 017 000
Barley	3 500	*1.8	6 500
Cotton	67 000	3.6	241 000
Sorghum, Grain	17 000	2.5	42 500
Sudan	26 000	2.5	65 000
Sugar Beets	74 000	3.7	274 000
Wheat	146 500	2.1	307 500
Misc. Field Crops	13 500	*2.5	34 000
Melons	12 500	*2.3	29 000
Lettuce	44 500	1.4	62 500
Carrots	7 500	1.3	10 000
Tomatoes	3 500	2.3	8 000
Misc. Garden Crops	11 500	1.7	19 500
Citrus	2 000	3.8	7 500
Misc. Permanent Crops	14 000	4.2	59 000
Total	612 500	3.56	2 183 000

Net acres irrigated 458 500

Consumptive use per net acre irrigated - 4.76

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED
1977
(Acres in crop to nearest 500 acres)

		Consumptive Use	
	Acres	1/ Ac. Ft. per Ac.	Ac. Ft.
Alfalfa	178 000	6.0	1 068 000
Barley	7 000	*1.8	12 500
Cotton	138 000	3.6	497 000
Sorghum, Grain	7 000	2.5	17 500
Sudan	6 500	2.5	16 500
Sugar Beets	60 000	3.7	222 000
Wheat	67 500	2.1	141 500
Misc. Field Crops	12 000	*2.5	30 000
Melons	15 000	*2.3	34 500
Lettuce	39 500	1.4	55 500
Carrots	4 500	1.3	6 000
Tomatoes	4 500	2.3	10 500
Misc. Garden Crops	11 000	1.7	18 500
Citrus	2 000	3.8	7 500
Misc. Permanent Crops	12 500	4.2	52 500
Total	565 000	3.88	2 190 000

Net acres irrigated 460 000

Consumptive use per net acre irrigated - 4.76

1/ Kaddah, M. T. and Rhoades, J. R., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED
1978
(Acres in crop to nearest 500 acres)

		Consumptive Use	
	Acres	1/ Ac. Ft. Per Ac.	Ac. Ft.
Alfalfa	180 500	6.0	1 083 000
Barley	7 500	*1.8	13 500
Cotton	61 500	3.6	221 500
Sorghum, Grain	15 000	2.5	37 500
Sudan	12 000	2.5	30 000
Sugar Beets	36 500	3.7	135 000
Wheat	135 500	2.1	284 500
Misc. Field Crops	20 000	*2.5	50 000
Melons	17 000	*2.3	39 000
Lettuce	41 500	1.4	58 000
Carrots	6 500	1.3	8 500
Tomatoes	3 500	2.3	8 000
Misc. Garden Crops	16 500	1.7	28 000
Citrus	2 000	3.8	7 500
Misc. Permanent Crops	11 500	4.2	48 500
Total	567 000	3.62	2 052 500

Net acres irrigated - 452 000

Consumptive use per net acre irrigated - 4.54

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED
1979
(Acres in crop to nearest 500 acres)

		Consumptive Use	
	Acres	1/ Ac. Ft. Per Ac.	Ac. Ft.
Alfalfa	191 500	6.0	1 149 000
Barley	4 000	*1.8	7 000
Cotton	83 000	3.6	299 000
Sorghum, Grain	8 500	2.5	21 000
Sudan	24 500	2.5	61 000
Sugar Beets	48 000	3.7	177 500
Wheat	100 000	2.1	210 000
Misc. Field Crops	14 500	*2.5	36 500
Melons	15 500	*2.3	35 500
Lettuce	43 500	1.4	61 000
Carrots	9 000	1.3	11 500
Tomatoes	3 000	2.3	7 000
Misc. Garden Crops	18 000	1.7	30 500
Citrus	1 500	3.8	5 500
Misc. Permanent Crops	12 000	4.2	50 500
TOTAL	576 500	3.75	2 162 500

Net acres irrigated: 460 000

Consumptive use per net acre irrigated: 4.70

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED
1980

(Acres in crop to nearest 500 acres)

		Consumptive Use	
	Acres	1/ Ac. Ft. Per Ac.	Ac. Ft.
Alfalfa	189 500	6.0	1 137 000
Barley	2 000	*1.8	3 500
Cotton	83 500	3.6	300 500
Sorghum, Grain	4 000	2.5	10 000
Sudan	20 500	2.5	51 000
Sugar Beets	37 000	3.7	137 000
Wheat	142 000	2.1	298 000
Misc. Field Crops	8 500	*2.5	21 000
Melons	17 000	*2.3	39 000
Lettuce	44 500	1.4	62 500
Carrots	7 500	1.3	9 500
Tomatoes	1 500	2.3	3 500
Misc. Garden Crops	16 500	1.7	28 000
Citrus	1 500	3.8	5 500
Misc. Permanent Crops	12 500	4.2	52 500
Total	588 000	3.67	2 158 500

Net acres irrigated: 460 500

Consumptive use per net acre irrigated: 4.69

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

*Based on Blaney-Criddle formula

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREAS CROPPED

1981
(Acres in crop to nearest 500 acres)

		Consumptive Use	
	Acres	1/ Ac. Ft. Per Ac.	Ac. Ft.
Alfalfa	174 500	6.0	1 047 000
Barley	500	*1.8	1 000
Cotton	80 000	3.6	288 000
Sorghum, Grain	2 500	2.5	6 500
Sudan	22 000	2.5	55 000
Sugar Beets	44 000	3.7	163 000
Wheat	164 500	2.1	345 500
Misc. Field Crops	13 000	*2.5	32 500
Melons	21 500	*2.3	49 500
Lettuce	37 000	1.4	52 000
Carrots	7 000	1.3	9 000
Tomatoes	3 500	2.3	8 000
Misc. Garden Crops	16 000	1.7	27 000
Citrus	1 500	3.8	5 500
Misc. Permanent Crops	13 000	4.2	54 500
TOTAL	600 500	3.57	2 144 000

Net acres irrigated - 464,500

Consumptive use per net acre irrigated - 4.62

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and Water balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
CONSUMPTIVE USE OF AREA CROPPED
1982
(Acres in crop to nearest 500 acres)

		Consumptive Use	
	Acres	1/ Ac. Ft. Per Ac.	Ac. Ft.
Alfalfa	203 000	6.0	1 218 000
Barley	0	*1.8	0
Cotton	42 000	3.6	151 000
Sorghum, Grain	2 500	2.5	6 500
Sudan	8 000	2.5	20 000
Sugar Beets	37 500	3.7	139 000
Wheat	175 000	2.1	367 500
Misc. Field Crops	19 500	*2.5	49 000
Melons	24 000	*2.3	55 000
Lettuce	31 000	1.4	43 500
Carrots	9 000	1.3	11 500
Tomatoes	3 000	2.3	7 000
Misc. Garden Crops	21 500	1.7	36 500
Citrus	1 500	3.8	5 500
Misc. Permanent Crops	17 000	4.2	71 500
TOTAL	594 500	3.67	2 181 500

Net Acres Irrigated - 465,500

Consumptive use per net acre irrigated - 4.69

1/ Kaddah, M. T. and Rhoades, J. D., 1976, Salt and Water Balance in Imperial Valley, California: Soil Science Society of America Journal, v. 40, No. 1, pages 93-100.

* Based on Blaney-Criddle formula.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement-Imperial Unit
(Thousands of Acre-Feet)

1973-1982 Average

Year	Acres of * Crop	Irrigated * Acres	C.U. * (Ac. Ft.)	L.R. * (Ac. Ft.)	C.U.+L.R.
1973	561.0	444.5	2 059.0	369.0	2 428.0
1974	573.0	450.5	2 064.5	362.5	2 427.0
1975	585.0	456.5	2 044.5	360.0	2 404.5
1976	612.5	458.5	2 183.0	372.0	2 555.0
1977	565.0	460.0	2 190.0	364.0	2 554.0
1978	567.0	452.0	2 052.5	354.5	2 407.0
1979	576.5	460.0	2 162.5	381.5	2 554.0
1980	588.0	460.5	2 158.5	372.5	2 531.0
1981	600.5	464.5	2 144.0	379.0	2 523.0
1982	594.5	465.5	2 181.5	421.0	2 602.5
10-Year Average	582.5	457.0	2 124.0	373.5	2 497.5

AF/A 10-Year Average Leaching Requirement $= \dfrac{CU+LR}{Ac.\ Irr.} - \dfrac{CU}{Ac.\ Irr.}$

$$= \frac{2\,497.5}{457.0} - \frac{2\,124.0}{457.0}$$

$$= 5.46 - 4.65 = 0.81$$

$$L.R.\ \% = \frac{0.81}{5.46} \times 100 = 14.8\%$$

*Refer to pages 14 to 23

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1973

Average Yearly EC of Incoming Irrigation Water = 1.24 mmhos/cm

*Leaching Requirement = $\dfrac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	176 000	6.0	1 056 000	8	16	1.1	193 500
Barley	17 500	1.8	31 500	13.5	9	0.2	3 500
Cotton	37 000	3.6	133 000	16	8	0.3	11 000
Sorghum, Grain	39 500	2.5	99 000	12	10	0.3	12 000
Sudan	13 000	2.5	32 500	10	12	0.3	4 000
Sugar Beets	70 000	3.7	259 000	16	8	0.3	21 000
Wheat	94 500	2.1	198 500	14	9	0.2	19 000
Misc. Field Crops	26 000	2.5	65 000	8	16	0.5	13 000
Melons	13 000	2.3	30 000	3.5	35	1.2	15 500
Lettuce	41 000	1.4	57 500	5	25	0.5	20 500
Carrots	5 000	1.3	6 500	4	31	0.6	3 000
Tomatoes	2 500	2.3	6 000	8	16	0.4	1 000
Misc. Garden Crops	9 500	1.7	16 000	6	21	0.5	5 000
Citrus	2 500	3.8	9 500	3	41	2.6	6 500
Misc. Permanent Crops	14 000	4.2	59 000	3	41	2.9	40 500
(Crops)	561 000	3.67	2 059 000	8.3	15	0.66	369 000
(Irrigated)	444 500	4.63	2 059 000	8.3	15	0.83	344 500

*U. S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U. S. D. A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1974

Average Yearly EC of Incoming Irrigation Water = 1.25 mmhos/cm

*Leaching Requirement = $\frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	158 000	6.0	948 000	8	16	1.1	174 000
Barley	5 500	1.8	10 000	13.5	9	0.2	1 000
Cotton	79 000	3.6	284 500	16	8	0.3	23 500
Sorghum, Grain	31 500	2.5	79 000	12	10	0.3	9 500
Sudan	14 500	2.5	36 500	10	13	0.4	6 000
Sugar Beets	69 000	3.7	255 500	16	8	0.3	20 500
Wheat	101 500	2.1	213 000	14	9	0.2	20 500
Misc. Field Crops	16 500	2.5	41 500	8	16	0.5	8 500
Melons	11 000	2.3	25 500	3.5	36	1.4	15 500
Lettuce	48 500	1.4	68 000	5	25	0.5	24 500
Carrots	6 500	1.3	8 500	4	31	0.6	4 000
Tomatoes	3 000	2.3	7 000	8	16	0.4	1 000
Misc. Garden Crops	12 500	1.7	21 500	6	21	0.5	6 500
Citrus	2 500	3.8	9 500	3	42	2.8	7 000
Misc. Permanent Crops	13 500	4.2	56 500	3	42	3.0	40 500
(Crops)	573 000	3.60	2 064 500	8.3	15	0.63	362 500
(Irrigated)	450 500	4.58	2 064 500	8.3	15	0.80	334 500

*U. S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U. S. D. A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT

Leaching Requirement of Areas Cropped

1975

Average Yearly EC of Incoming Irrigation Water = 1.25 mmhos/cm

$$\text{*Leaching Requirement} = \frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	159 500	6.0	957 000	8	16	1.1	175 500
Barley	3 500	1.8	6 500	13.5	9	0.2	500
Cotton	43 000	3.6	155 000	16	8	0.3	13 000
Sorghum, Grain	24 500	2.5	61 500	12	10	0.3	7 500
Sudan	13 000	2.5	32 500	10	13	0.4	5 000
Sugar Beets	71 500	3.7	264 500	16	8	0.3	21 500
Wheat	155 500	2.1	326 500	14	9	0.2	31 000
Misc. Field Crops	16 000	2.5	40 000	8	16	0.5	8 000
Melons	11 500	2.3	26 500	3.5	36	1.4	16 000
Lettuce	45 000	1.4	63 000	5	25	0.5	22 500
Carrots	6 000	1.3	8 000	4	31	0.6	3 500
Tomatoes	6 000	2.3	14 000	8	16	0.4	2 500
Misc. Garden Crops	15 000	1.7	25 500	6	21	0.5	7 500
Citrus	2 500	3.8	9 500	3	42	2.8	7 000
Misc. Permanent Crops	13 000	4.2	54 500	3	42	3.0	39 000
(Crops)	585 000	3.49	2 044 500	8.3	15	0.62	360 000
(Irrigated)	456 500	4.48	2 044 500	8.3	15	0.79	332 500

*U. S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U. S. D. A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1976

Average Yearly EC of Incoming Irrigation Water = 1.23 mmhos/cm

$$\text{*Leaching Requirement} = \frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	169 500	6.0	1 017 000	8	15	1.1	186 500
Barley	3 500	1.8	6 500	13.5	9	0.2	500
Cotton	67 000	3.6	241 000	16	8	0.3	20 000
Sorghum, Grain	17 000	2.5	42 500	12	10	0.3	5 000
Sudan	26 000	2.5	65 000	10	12	0.3	8 000
Sugar Beets	74 000	3.7	274 000	16	8	0.3	22 000
Wheat	146 500	2.1	307 500	14	9	0.2	29 500
Misc. Field Crops	13 500	2.5	34 000	8	15	0.4	5 500
Melons	12 500	2.3	29 000	3.5	35	1.2	15 000
Lettuce	44 500	1.4	62 500	5	25	0.5	22 500
Carrots	7 500	1.3	10 000	4	31	0.6	4 500
Tomatoes	3 500	2.3	8 000	8	15	0.4	1 500
Misc. Garden Crops	11 500	1.7	19 500	6	21	0.5	6 000
Citrus	2 000	3.8	7 500	3	41	2.6	5 000
Misc. Permanent Crops	14 000	4.2	59 000	3	41	2.9	40 500
(Crops)	612 500	3.56	2 183 000	8.2	15	0.61	372 000
(Irrigated)	458 500	4.76	2 183 000	8.2	15	0.81	347 500

*U. S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U. S. D. A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1977

Average Yearly EC of Incoming Irrigation Water = 1.22 mmhos/cm

*Leaching Requirement = $\frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	178 000	6.0	1 068 000	8	15	1.1	196 00
Barley	7 000	1.8	12 500	13.5	9	0.2	1 50
Cotton	138 000	3.6	497 000	16	8	0.3	41 50
Sorghum, Grain	7 000	2.5	17 500	12	10	0.3	2 00
Sudan	6 500	2.5	16 500	10	12	0.3	2 00
Sugar Beets	60 000	3.7	222 000	16	8	0.3	18 00
Wheat	67 500	2.1	141 500	14	9	0.2	13 50
Misc. Field Crops	12 000	2.5	30 000	8	15	0.4	5 00
Melons	15 000	2.3	34 500	3.5	35	1.2	18 00
Lettuce	39 500	1.4	55 500	5	24	0.4	16 00
Carrots	4 500	1.3	6 000	4	31	0.6	2 50
Tomatoes	4 500	2.3	10 500	8	15	0.4	2 00
Misc. Garden Crops	11 000	1.7	18 500	6	20	0.4	4 50
Citrus	2 000	3.8	7 500	3	41	2.6	5 00
Misc. Permanent Crops	12 500	4.2	52 500	3	41	2.9	36 50
(Crops)	565 000	3.88	2 190 000	8.7	14	0.64	364 00
(Irrigated)	460 000	4.76	2 190 000	8.7	14	0.77	364 00

*U. S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U. S. D. A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1978

Average Yearly EC of Incoming Irrigation Water = 1.17 mmhos/cm

*Leaching Requirement = $\frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR%	AF/A	AF
Alfalfa	180 500	6.0	1 083 000	8	15	1.1	198 500
Barley	7 500	1.8	13 500	13.5	9	0.2	1 500
Cotton	61 500	3.6	221 500	16	7	0.3	18 500
Sorghum, Grain	15 000	2.5	37 500	12	10	0.3	4 500
Sudan	12 000	2.5	30 000	10	12	0.3	3 500
Sugar Beets	36 500	3.7	135 000	16	7	0.3	11 000
Wheat	135 500	2.1	284 500	14	8	0.2	27 000
Misc. Field Crops	20 000	2.5	50 000	8	15	0.4	8 000
Melons	17 000	2.3	39 000	3.5	33	1.1	18 500
Lettuce	41 500	1.4	58 000	5	23	0.4	16 500
Carrots	6 500	1.3	8 500	4	29	0.5	3 500
Tomatoes	3 500	2.3	8 000	8	15	0.4	1 500
Misc. Garden Crops	16 500	1.7	28 000	6	19	0.4	6 000
Citrus	2 000	3.8	7 500	3	39	2.4	5 000
Misc. Permanent Crops	11 500	4.2	48 500	3	39	2.7	31 000
(Crops)	567 000	3.62	2 052 500	7.8	15	0.62	354 500
(Irrigated)	452 000	4.54	2 052 500	7.8	15	0.78	354 500

*U. S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U.S.D.A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1979

Average Yearly EC of Incoming Irrigation Water = 1.24 mmhos/cm

$$\text{*Leaching Requirement} = \frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	191 500	6.0	1 149 000	8	15	1.1	210 500
Barley	4 000	1.8	7 000	13.5	9	0.2	1 000
Cotton	83 000	3.6	299 000	16	8	0.3	25 000
Sorghum, Grain	8 500	2.5	21 000	12	10	0.3	2 500
Sudan	24 500	2.5	61 000	10	12	0.3	7 500
Sugar Beets	48 000	3.7	177 500	16	8	0.3	14 500
Wheat	100 000	2.1	210 000	14	9	0.2	20 000
Misc. Field Crops	14 500	2.5	36 500	8	15	0.4	6 000
Melons	15 500	2.3	35 500	3.5	35	1.2	18 500
Lettuce	43 500	1.4	61 000	5	25	0.5	21 500
Carrots	9 000	1.3	11 500	4	31	0.6	5 500
Tomatoes	3 000	2.3	7 000	8	15	0.4	1 000
Misc. Gardens Crops	18 000	1.7	30 500	6	21	0.5	9 000
Citrus	1 500	3.8	5 500	3	41	2.6	4 000
Misc. Permanent Crops	12 000	4.2	50 500	3	41	2.9	35 000
(Crops)	576 500	3.75	2 162 500	8.3	15	0.66	381 500
(Irrigated)	460 000	4.70	2 162 500	8.3	15	0.83	381 500

*U.S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U. S. D. A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Acres Cropped
1980

Average Yearly EC of Incoming Irrigation Water = 1.19 mmhos/cm

$$\text{*Leaching Requirement} = \frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	** mmhos/cm	LR(%)	AF/A	AF
Alfalfa	189 500	6.0	1 137 000	8	15	1.1	208 500
Barley	2 000	1.8	3 500	13.5	9	0.2	500
Cotton	83 500	3.6	300 500	16	7	0.3	25 000
Sorghum, Grain	4 000	2.5	10 000	12	10	0.3	1 000
Sudan	20 500	2.5	51 000	10	12	0.3	6 000
Sugar Beets	37 000	3.7	137 000	16	7	0.3	11 000
Wheat	142 000	2.1	298 000	14	9	0.2	28 500
Misc. Field Crops	8 500	2.5	21 000	8	15	0.4	3 500
Mellons	17 000	2.3	39 000	3.5	34	1.2	20 500
Lettuce	44 500	1.4	62 500	5	24	0.4	18 000
Carrots	7 500	1.3	9 500	4	30	0.6	4 500
Tomatoes	1 500	2.3	3 500	8	15	0.4	500
Misc. Garden Crops	16 500	1.7	28 000	6	20	0.4	6 500
Citrus	1 500	3.8	5 500	3	40	2.5	3 500
Misc. Permanent Crops	12 500	4.2	52 500	3	40	2.8	35 000
(Crops)	588 000	3.67	2 158 500	7.9	15	0.63	372 500
(Irrigated)	460 500	4.69	2 158 500	7.9	15	0.81	372 500

*U.S. Department of Agriculture Handbook No. 60, p. 37.

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and USDA Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1981

Average Yearly EC of Incoming Irrigation Water = 1.25 mmhos/cm

*Leaching Requirement = $\frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	174 500	6.0	1 047 000	8	16	1.1	192 000
Barley	500	1.8	1 000	13.5	9	0.2	0
Cotton	80 000	3.6	288 000	16	8	0.3	24 000
Sorghum, Grain	2 500	2.5	6 500	12	10	0.3	1 000
Sudan	22 000	2.5	55 000	10	12	0.3	6 500
Sugar Beets	44 000	3.7	163 000	16	8	0.3	13 000
Wheat	164 500	2.1	345 500	14	9	0.2	33 000
Misc. Field Crops	13 000	2.5	32 500	8	16	0.5	6 500
Melons	21 500	2.3	49 500	3.5	36	1.3	28 000
Lettuce	37 000	1.4	52 000	5	25	0.5	18 500
Carrots	7 000	1.3	9 000	4	31	0.6	4 000
Tomatoes	3 500	2.3	8 000	8	16	0.4	1 500
Misc. Garden Crops	16 000	1.7	27000	6	21	0.5	8 000
Citrus	1 500	3.8	5 500	3	42	2.8	4 000
Misc. Permanent Crops	13 000	4.2	54 500	3	42	3.0	39 000
(Crops)	600 500	3.57	2 144 000	8.3	15	0.63	379 000
(Irrigated)	464 500	4.62	2 144 000	8.3	15	0.82	379 000

*U.S. Department of Agriculture Handbook No. 60, p. 37

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U.S.D.A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Leaching Requirement of Areas Cropped
1982

Average Yearly EC of Incoming Irrigation Water = 1.28 mmhos/cm

*Leaching Requirement = $\frac{\text{EC of Incoming Irrigation Water}}{\text{EC of Soil Saturation Extract}}$

	Consumptive Use			Leaching Requirement			
	Acres	AF/A	AF	**mmhos/cm	LR(%)	AF/A	AF
Alfalfa	203 000	6.0	1 218 000	8	16	1.1	223 500
Barley	0	1.8	0	13.5	9	0.2	0
Cotton	42 000	3.6	151 000	16	8	0.3	12 500
Sorghum, Grain	2 500	2.5	6 500	12	11	0.3	1 000
Sudan	8 000	2.5	20 000	10	13	0.4	3 000
Sugar Beets	37 500	3.7	139 000	16	8	0.3	11 500
Wheat	175 000	2.1	367 500	14	9	0.2	35 000
Misc. Field Crops	19 500	2.5	49 000	8	16	0.5	9 500
Melons	24 000	2.3	55 000	3.5	37	1.4	33 500
Lettuce	31 000	1.4	43 500	5	26	0.5	15 500
Carrots	9 000	1.3	11 500	4	32	0.6	5 500
Tomatoes	3 000	2.3	7 000	8	16	0.4	1 000
Misc. Garden Crops	21 500	1.7	36 500	6	21	0.5	10 500
Citrus	1 500	3.8	5 500	3	43	2.9	4 500
Misc. Permanent Crops	17 000	4.2	71 500	3	43	3.2	54 500
(Crops)	594 500	3.67	2 181 500	8.0	16	0.71	421 000
(Irrigated)	465 500	4.69	2 181 500	8.0	16	0.90	421 000

*U.S. Department of Agriculture Handbook No. 60, p. 37

**EC of soil saturation extract that will reduce crop yield by not more than 10% from Drainage of Agriculture edited by J. V. Schilfgaarde, p. 73, and U.S.D.A. Bulletin No. 283, pages 10-12.

IMPERIAL IRRIGATION DISTRICT
Distribution Present Uses - Imperial Unit
1973 1982

	ACRE-FEET X 1,000												
	1973	1974	1975	1976	1975	1976	1977	1978	1979	1980	1981	1982	10-Year Average
1. To I.I.D. at Drop #1	2 956	3 072	3 001	2 784	3 001	2 784	2 693	2 672	2 803	2 769	2 769	2 516	2 804
2. Loss, Drop #1 to E.H.L.	61	75	58	33	58	33	22	24	8	34	23	19	36
3. Loss, E.H.L. to W.S.M.	16	15	9	19	9	19	18	23	12	30	21	17	18
4. Gross A.A. Canal Loss (2+3)	77	91	67	52	67	52	40	47	20	64	44	36	54
5. Canal Loss and Regulation	197	197	222	207	222	207	190	170	194	172	219	228	200
6. Total I.I.D. Losses (4+5)	274	288	289	259	289	259	230	217	214	236	263	264	253
7. Spill for System Regulation	10	5	7	7	7	7	6	10	11	8	6	4	7
8. Total Loss & System Regulation (6+7)	284	293	296	266	296	266	236	227	225	244	269	268	261
9. Total Deliveries to Users (1-8)	2 672	2 779	2 705	2 518	2 705	2 518	2 457	2 445	2 578	2 525	2 500	2 248	2 543
10. Water Conveyance Efficiency (100x9÷1)	90.4	90.5	90.1	90.4	90.1	90.4	91.2	91.5	92.0	91.2	90.3	89.3	90.7
11. Gross Acres of Crops	560.5	573.5	585.5	613.0	585.5	613.0	565.0	567.0	576.5	588.0	600.5	594.5	582.5
12. Net Acres Irrigated	444.5	450.0	456.5	458.5	456.5	458.5	460.0	452.0	460.0	460.5	464.5	465.5	457.0
13. Delivered to Users Ac. Ft./Ac. of Crop (9÷11)	4.77	4.85	4.62	4.11	4.62	4.11	4.35	4.31	4.47	4.29	4.16	3.78	4.37
14. Delivered to Users Ac. Ft./Ac. Irrigated (9÷12)	6.01	6.18	5.93	5.49	5.93	5.49	5.35	5.41	5.60	5.48	5.38	4.83	5.56
15. At Drop #1 Ac. Ft./Ac. Irrigated (1÷12)	6.65	6.83	6.57	6.07	6.57	6.07	5.85	5.91	6.09	6.01	5.96	5.40	6.13

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ATTAINABLE IRRIGATION EFFICIENCIES[a]

By Lyman S. Willardson,[1] M. ASCE

INTRODUCTION

The earliest expression of the need for irrigation efficiency was reflected in the development of the term duty of water. Shortly after modern irrigation began in the west, it was apparent that the water supply would not be adequate. It was also obvious that some irrigators were using more water than others. Scientists (9,10) tried to determine the amount of water required to produce various crops and used the term duty of water to define this amount. The term was also used to evaluate the quantity of water required to produce a given weight of crop. This dual definition of the term led to some confusion.

A more precise definition of irrigation efficiency was required for water management purposes and in 1932, Israelsen (7) developed a definition for water application efficiency. He was concerned with water application on a single field and with determining the proportion of water applied to the field that was actually retained in the root zone. Since these early beginnings, other workers in irrigation have developed, refined, and redefined irrigation efficiency terms.

The general objective of irrigation is to provide a suitable moisture environment in the soil for plant growth. The water applied must be uniformly distributed over the soil surface. The amount applied should not exceed the available water storage capacity of the soil profile in the root zone, plus any leaching requirement. Overirrigation and leaching of nutrients should be avoided. Underirrigation that allows salts to accumulate in the soil and may cause plant water stress is undesirable. Water should be applied with the greatest uniformity possible with minimum water management losses. Erosion

Note.—Discussion open until November 1, 1972. Separate discussions should be submitted for the individual papers in this symposium. To extend the closing date one month, a written request must be filed with the Executive Director, ASCE. This paper is part of the copyrighted Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 98, No. IR2, June, 1972. Manuscript was submitted for review for possible publication on January 18, 1972.

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and deterioration of soil structure should be minimized. All of these requirements could be included and evaluated as irrigation efficiency.

IRRIGATION EFFICIENCY DEFINITIONS

There are at least 20 currently used definitions of irrigation efficiency. Israelsen (7) published some of the earliest definitions and later researchers (4,8,11) have used other definitions. When a definition of irrigation efficiency is used, the terms in the equation should be specified to avoid misunderstandings.

Concern for a particularly defined irrigation efficiency is determined in some degree by the individual's interest or need. The efficient application of water to a small plot of a specialty crop may be of vital concern to a farmer but will be of lesser interest to a river basin planner who is looking at an overall water supply. Diversions to other basins or preservation of a limited water supply may require interest in irrigation efficiency at all planning levels. Understanding the concept of consumptive use and plant water requirements should make it possible to decide which irrigation efficiency is important.

Efficiency is computed to determine how well a particular goal is being reached. Since the goals of all determinations of irrigation efficiencies are not defined herein, no attempt will be made to define all possible irrigation efficiencies.

WATER FOR CULTURAL PRACTICES

The description of irrigation efficiency which follows will not include the efficiency of use of water for cultural practices. Erie (3) has listed a number of reasons for applying water other than to replenish water in the root zone: to aid germination; to protect from frost; to control corn borers and caterpillars; to aid growth of potato tubers; to rewet the surface soil after crop thinning; to maintain crispness in lettuce and other vegetables during harvest; to leach salts; to dissolve fertilizers; and to control temperature. Efficiencies of water applied for these purposes will not be treated herein.

FACTORS CONTROLLING IRRIGATION EFFICIENCIES

This paper will be concerned with irrigation efficiencies on a single field. The important efficiency factors will depend on the type of irrigation system used, and the physical, economic, and political constraints. There are also many judgment factors involved, and irrigation efficiency is now mainly controlled by the skill of the irrigator.

The irrigation efficiency to be considered herein is primarily that termed water application efficiency by Israelsen. This is the percentage of the water applied that is actually stored in the root zone for use by the crops. The uniformity of water absorption over the field directly affects water application efficiency.

The physical factors that affect water application efficiency are those related to the infiltration and storage of water in the soil. In surface irrigation, the slope and roughness of the soil surface, the soil infiltration characteristics, the stream size, and the volume of soil available for water storage are among the important considerations because they also affect the uniformity of distribution. For sprinkler irrigation, sprinkler spacing, nozzle size, and pressure are important for the same reason. The wind conditions may be very important at certain times.

TABLE 1.—WATER APPLICATION EFFICIENCIES, MILFORD, UTAH, 1959, POTATO FIELD, FARM NO. 35

Date of irrigation (1)	Water applied, in inches (2)	Water stored, in inches (3)	Application efficiency, as a percentage (4)
June 10-15	8.4	3.1	37
July 9-12	4.9	3.7	77
July 19-20	3.5	.9	26
July 26-27	3.1	.9	29
August 2-3	3.7	.9	24
August 9-10	3.4	1.3	38
August 16-17	3.9	1.7	44
August 23-24	3.7	1.8	49
August 30-31	3.1	2.7	87
September 6-7	3.7	2.2	59
September 13-15	3.7	1.5	41
Totals	45.1	20.7	Average 46

1 in. = 25.4 mm.

TABLE 2.—WATER DISTRIBUTION EFFICIENCIES, MILFORD, UTAH, 1958-1959, POTATO FIELD, FARM NO. 35, FURROW IRRIGATION SYSTEM

Date of irrigation (1)	Distribution efficiency, as a percentage (2)
June 10-15	79
July 9-12	88
July 19-20	87
July 26-27	69
August 2-3	69
August 9-10	86
August 16-17	96
August 23-24	96
August 30-31	82
September 6-7	86
September 13-15	81
	Average 84

Economic factors that may directly or indirectly affect water application efficiency are water costs and their relation to land preparation costs and labor costs, equipment costs, and the value of the crop being irrigated.

Political factors that may affect irrigation efficiencies are water laws and geographical location. Most appropriation water law is set up on the basis of the use of water being beneficial. What is beneficial use in terms of irrigation efficiency has never been adequately defined. Until precise definitions are written into law, political influence on irrigation efficiency will probably be toward lower rather than higher efficiencies.

WATER DISTRIBUTION

One major controlling factor in attainable irrigation efficiency is the water storage capacity in the soil at the time of irrigation relative to the amount applied and the uniformity of application. If, for example, it were physically and practically possible to distribute a 4-in. depth of irrigation water with absolute uniformity over a field which could only store 1-in. in the root zone, regardless of the precision and uniformity of the irrigation, the water application efficiency would be 25 %. This fact is relatively unrecognized by many irrigators. Table 1 shows data from a sequence of furrow irrigations on a potato field (12). The amount of water applied was nearly uniform during every irrigation; however, the amount of water stored in the soil varied greatly. Efficiency of water application varied between 24 % and 87 % during the season, depending on the available soil moisture storage capacity. The available moisture storage capacity at the time of irrigation can override all other factors in determining irrigation efficiency.

Uniformity of water application over a field is important also. An average application amount will be meaningful only if distribution is relatively uniform. Table 2 shows distribution efficiencies (1) for the same irrigations given in Table 1. Applying water nonuniformly will result in overirrigation with associated deep percolation losses in some areas and underirrigation with associated plant water stress in other areas.

It is possible to irrigate with a water application efficiency of 100 % every time by applying less water than the soil will hold at any location. For example, if the soil has a water deficiency of 12 in. and 1 in. is applied with reasonable uniformity, water application efficiency will be 100 % in every location on the field. However, the crop will not grow well. Underirrigation is obviously not the solution to the irrigation efficiency problem.

SURFACE IRRIGATION EFFICIENCY

Surface irrigation has one overriding disadvantage related to water distribution because the same surface used to absorb the water is also used as the transporting medium. The time differences developed in moving water over the surface result in nonuniform distribution.

The water intake characteristics of the soil largely determine the ease with which water can be relatively uniformly distributed over the surface. In general, the lower the infiltration rate, the simpler it is to obtain a uniform irrigation. Willardson and Bishop (11) have shown that it is relatively easy to obtain water application efficiencies above 60 % over a wide range of furrow stream or border stream advance conditions. Efficiencies range above 70 % on low intake rate soils. These water application efficiency values are predicated on a full irrigation over the entire field with no recovery of runoff water or adjustments to reduce runoff. If runoff water can be recovered, water

application efficiencies can be boosted above 80 %.

The change in infiltration characteristics of the soil with time very much complicates the problem of obtaining efficient surface application of water. Areal variations of intake rates within fields also cause problems. Light irrigations tend to be less efficient than heavier irrigations because of low uniformity of distribution. Another factor affecting water application efficiency is the areal variation of available soil water storage capacity that is a result of previous nonuniform water applications.

Various irrigation methods have been tried to eliminate time differentials in surface irrigation. Level basin irrigation in which large volumes of water were applied over a very short period to an enclosed area is one example. Runoff losses are eliminated and all the water applied is absorbed. It is presumed that water distribution over the field is uniform since the differences in intake opportunity time over the field are very small. However, water will percolate more rapidly into the more porous areas of any surface irrigated field, causing nonuniform distribution. High and low spots in the field also affect distribution uniformity significantly.

The problem of advance time is very apparent for furrow and border irrigation systems where lengths of run are very long. As indicated earlier, soils with low intake rates will allow the use of long lengths of run with reasonably efficient results. High infiltration rates soils are difficult to irrigate by any surface method. Obtainable efficiencies in surface irrigation depend entirely on the possibility of uniform distribution of water over the soil surface and uniform infiltration. With coefficients of uniformity above 80 %, water application efficiencies of surface irrigation can be as high as 80 %, if the water storage capacity of the root zone is not exceeded.

TRICKLE IRRIGATION EFFICIENCY

Trickle irrigation is coming into vogue in many parts of the world. Many countries are expressing interest in response to claims of very efficient use of water. Manufacturers of commercial trickle irrigation equipment are claiming anywhere from 50 % to 90 % reduction in irrigation water needs through the use of trickle irrigation. This is equivalent to irrigation water use efficiencies of 200 % and 1,000 % computed on a gross area basis. Research data (2) show water savings of 15 % to 50 % of the amounts usually applied by surface irrigation.

Research work in Israel indicates that when using equivalent amounts of water, yields are approximately doubled by trickle irrigation. No water is saved because leaching is needed periodically for salinity control, but the duty of water is increased. No claims related to water application efficiency were made. Estimates of a 50 % reduction in water requirements for trickle irrigation are based on the fact that only a small portion of the soil surface is wetted by irrigation and, therefore, surface evaporation of water is reduced. With trickle irrigation, as with surface irrigation, it is possible to irrigate with a true water application efficiency of 100 % by underirrigating so that no water is lost to runoff or deep percolation.

There have been no evaluations published of deep percolation losses under trickle irrigation. The efficiency obtained will depend on the spacing of the emitters and the rate of water application relative to the evapotranspiration rate. Even though the soil surface evaporation losses are minimized, deep percolation losses are possible if application exceeds evapotranspiration.

SPRINKLER IRRIGATION EFFICIENCY

Sprinkler irrigation is a means of applying water with relative independence from the infiltration characteristics of the soil. As long as the infiltration and water transmission rates of the soil are not exceeded, water can be applied to the soil surface at any suitable rate and in any amount. Water application efficiency is, therefore, directly related to the uniformity and amount of water application.

In 1964 Howell (6), in a paper entitled "Non-uniformity and Sprinkler Application Efficiency," described three special cases of water application: (1)

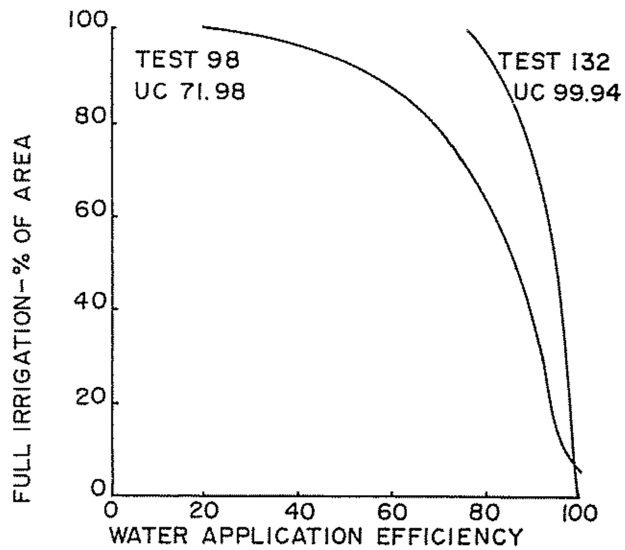

FIG. 1.—SPRINKLER IRRIGATION EFFICIENCY

When the greatest precipitation is less than or equal to that required to bring the full root zone depth to field capacity; (2) when the mean depth of application is just sufficient to bring the full root zone depth to field capacity; and (3) when the application has been increased to the extent that the minimum application depth encountered on the area is just enough to bring the full root zone to field capacity. Needless to say, water application efficiencies are different in each of the three cases.

Fig. 1 shows data from uniformity of water application tests conducted at the Imperial Valley Conservation Research Center, Brawley, Calif. by Hermsmeier (5). One test (No. 132) had a uniformity coefficient of 99.94 % and the other (No. 98) had a uniformity coefficient of 71.98 %. For the three conditions listed by Howell, the water application efficiencies are 100 %, 86 %, and 20 %,

respectively, for Test No. 98. For Test No. 132, the corresponding water application efficiencies are 100 %, 95 %, and 75 %. These data emphasize the importance of uniformity of application in obtaining high water application efficiencies.

The distribution pattern of water under sprinkler irrigation can vary for the same coefficient of uniformity. This variation will affect water application efficiency. Test No. 132 shows that a nearly perfect coefficient of uniformity provided for only a 75 % water application efficiency when the field was all adequately irrigated.

CONCLUSIONS

Uniformity of water application is the key to high water application efficiency in any kind of irrigation. It is also important to limit the amount of water applied to that which can be stored in the root zone.

Uniformity of water application is difficult to attain in surface irrigation if light irrigations are required, if the soil has a high infiltration rate, and if the intake characteristics of the soil vary areally. Uniformity of water application by sprinklers depends on the characteristics of the sprinkler system and is directly related to the water distribution pattern. Low coefficients of uniformity result in low water application efficiency. Uniformity of trickle irrigation application has not been thoroughly investigated. Application of water with perfect uniformity will not result in a 100 percent water application efficiency if the storage capacity of the root zone is exceeded to any degree.

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8957 ATTAINABLE IRRIGATION EFFICIENCIES

KEY WORDS: **Irrigation; Irrigation efficiency; Sprinkler irrigation;** Subsurface irrigation; **Surface irrigation; Trickle irrigation;** Uniformity coefficient; **Water application rate; Water management (applied)**

ABSTRACT: Irrigation efficiency has many definitions. The concept appeared in print as early as 1887 expressed as duty of water. Later definitions are outlined. The efficiencies of water application for purposes other than refilling the rootzone have been mentioned but not described. The irrigation efficiency analyzed in detail is water application efficiency, defined as the percent of applied water that appears stored in the rootzone. Physical, economic, and political factors that affect water application efficiency are presented. Examples of water application efficiencies attainable in the field by surface, sprinkler, and trickle irrigation are given. Water application efficiencies are shown to be primarily affected by uniformity fo water distribution and the proportion of water applied that can be stored in the rootzone.

REFERENCE: Willardson, Lyman S., "Attainable Irrigation Efficiencies," *Journal of the Irrigation and Drainage Division*, ASCE, Vol. 98, No. IR2, **Proc. Paper 8957**, June, 1972, pp. 239-246

20-78

IMPERIAL IRRIGATION DISTRICT
Salinity of Irrigation Water Received
By District
& Leaching Requirement
(1959-1968)

Year	Annual Discharge A.F.* (1)	Total Salt Tons** (2)	Historic Wtd. Average T.A.F. (3)	Historic Wtd. Average P.P.M. (4)	Salinity K x 10^6*** (5)	Leaching Require. Percent (6) 1/
1959	2,840,173	2,852,019	1.00	735	1,050	17
1960	2,983,860	3,162,485	1.06	779	1,110	19
1961	2,957,200	3,330,087	1.13	831	1,190	20
1962	2,951,266	3,399,464	1.15	845	1,210	20
1963	2,991,429	3,378,583	1.13	831	1,190	20
1964	2,770,474	3,284,284	1.19	875	1,250	21
1965	2,624,363	3,406,457	1.30	956	1,370	23
1966	2,817,912	3,650,447	1.30	956	1,370	23
1967	2,719,861	3,306,261	1.22	897	1,280	21
1968	2,806,124	3,408,548	1.21	889	1,270	21
10 Yr. Avg.	2,846,266	3,317,863	1.17 2/	860 2/	1,230	21

*Total Discharge All-American Canal Below Drop 1

**Based on weekly salinity samples

***Based on conversion factor of 0.7 for ppm to conductivity (micromhos/cm. to nearest 10)

1/ Based on average salt tolerance for 50% yield reduction & historic conductance of water delivered to District - Refer USDA, Handbook No. 60 & Bulletin 283. Includes allowance for minimum nonuniformity of application.
2/ Weighted Average

Eng. Sec.
4/17/69

T-1057

IMPERIAL IRRIGATION DISTRICT
THEORETICAL DISTRIBUTION " DELIVERED TO USERS"
1959-1968

Year	Consumptive Use (1,000 AF)**	Delivered To Users 1/	Total Leaching Required 2/	Water Available For Farm Eff.-L.R.* 1,000 AF	Percent
1959	1,899	2,250	(5.20-4.32) x 440.0 = 387	(-36)	(101.6)
1960	1,894	2,396	(5.38-4.36) x 434.5 = 443	59	97.5
1961	1,840	2,415	(5.29-4.23) x 435.5 = 462	113	95.3
1962	1,774	2,446	(5.16-4.13) x 429.5 = 442	230	90.6
1963	1,852	2,513	(5.37-4.30) x 430.5 = 461	200	92.0
1964	1,893	2,399	(5.56-4.39) x 431.5 = 505	1	100.0
1965	1,839	2,312	(5.52-4.25) x 432.5 = 549	(-76)	(103.3)
1966	1,815	2,470	(5.39-4.15) x 437.5 = 543	112	95.5
1967	1,890	2,365	(5.37-4.24) x 445.5 = 503	(-27)	(101.1)
1968	1,782	2,476	(5.11-4.04) x 441.0 = 472	222	91.0
10 Yr. Average	1,848	2,404	(5.37-4.24) x 436.0 = 493 3/		

* Represents water that was available for farm loss after leaching requirement and consumptive use had been satisfied.

** Based on Blaney-Criddle Formula

1/ Refer T-1051

2/ (Total in 1,000 AF) Refer T-1059 for A.F. per irrigated acre

3/ Weighted Average

4/17/69

Eng. Sec.

T-1058

IMPERIAL IRRIGATION DISTRICT
WATER FOR CONSUMPTIVE USE AND LEACHING REQUIREMENT
AND THEORETICAL FARM EFFICIENCY
1959-1968

		Per Irrigated Acre								
Year	(1) Total Irrig Acres (1,000 AC)	(2) Cons. Use*	(3) Leach Require (Percent)	(4) C.U. + L.R. (2) x 100 / (100) - (3)	(5) L.R. Only (4) - (2)	(6) Total Delivered To Users	(7) Total C.U.* (1) x (2)	(8) Total L.R. (1) x (5)	(9) Avail. For F. E.** (6) - (7+8)	(10) F. Effic. (6-9)x100 / (6) **
1959	440.0	4.32	17	5.20	0.88	2,250	1,899	387	(-36)	(101.6)
1960	434.5	4.36	19	5.38	1.02	2,396	1,894	443	59	97.5
196[illegible]	435.5	4.23	20	5.29	1.06	2,415	1,840	462	113	95.3
1962	429.5	4.13	20	5.16	1.03	2,446	1,774	442	230	90.6
1963	430.5	4.30	20	5.37	1.07	2,513	1,852	461	200	92.0
1964	431.5	4.39	21	5.56	1.17	2,399	1,893	505	1	100.0
1965	432.5	4.25	23	5.52	1.27	2,312	1,839	549	(-76)	(103.3)
1966	437.5	4.15	23	5.39	1.24	2,470	1,815	543	112	95.5
1967	445.5	4.24	21	5.37	1.13	2,365	1,889	503	(-27)	(101.1)
1968	441.0	4.04	21	5.11	1.07	2,476	1,782	472	222	91.0
10 [illegible]r Average	436.0	4.24 1/	21	5.37 1/	1.13 1/	2,404	1,848	493 1/		

Note: Columns 1, 6, 7, 8, and 9 are in 1,000 A.F.

* Based on Blaney-Criddle formula
** Represents water that was available for farm losses after leaching requirement and consumptive use had been satisfied.

Column 2 refer T-1055
Column 3 refer T-1057
Column 6 refer T-1051

1/Weighted Average

4/17/69
Eng. Sec.

IMPERIAL IRRIGATION DISTRICT
INFLOW TO SALTON SEA - IID & MEXICO
1959-1968 (1,000 A.F.)

Year	From Mexico At Int. Boundary	From IID Operational Loss	From IID Farm Drainage	From IID Total IID	Total IID & Mexico
1959	124	88	933	1,021	1,145
1960	123	86	973	1,060	1,183
1961	117	78	973	1,051	1,168
1962	134	70	1,019	1,089	1,223
1963	141	67	1,087	1,154	1,295
1964	107	36	869	905	1,012
1965	113	27	856	883	996
1966	104	28	977	1,005	1,109
1967	98	26	1,002	1,028	1,126
1968	107	20	981	1,001	1,108
10 Year Average	117	53	967	1,020	1,137

4/17/69
Eng. Sec.

T-1060

IMPERIAL IRRIGATION DISTRICT
THEORETICAL DISTRIBUTION
"IID CONTRIBUTION TO SALTON SEA"
1959-1968 (1,000 A.F.)

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	10 Year Average
Leach Requirement 1/	387	443	462	442	461	505	549	543	503	472	493
Operational Loss	88	86	78	70	67	36	27	28	26	20	53
85% Canal Loss and Regulation*	476	491	462	417	410	317	297	330	322	313	383
50% Water avail. for Farm Efficiency**	___	30	57	115	100	___	___	56	___	111	47
Total Theoretical 2/	951	1,050	1,059	1,044	1,038	858	873	957	851	916	976
Observed to Sea 3/	1,021	1,060	1,051	1,089	1,154	905	883	1,005	1,028	1,001	1,020
Difference	-70	-10	+8	-45	-116	-47	-10	-48	-177	-85	-44

* Based on 15% allowance for surface evaporation and consumptive use of vegetation along and adjacent to canal section in Imperial Unit, Refer T-1052 "Total Canal Loss and Regulation".

**Estimated 50% of water available for farm losses after leaching requirement and crop consumptive use had been satisfied from amount of "deliveries to users"
Refer T-1059

1/Refer T-1059
2/Does not include contribution from rainfall
3/Includes contribution from rainfall

Eng. Sec.
4/17/69

IMPERIAL IRRIGATION DISTRICT
DISTRIBUTION PRESENT USES - IMPERIAL UNIT - 1959-1968

	Thousands of Acre-Feet										
	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	Avg. 10 Yrs.
To IID at Pilot Knob	2 898	3 060	3 036	3 006	3 062	2 808	2 688	2 886	2 770	2 864	2 908
Loss, P.K. to Drop 1 (IID)	58	76	79	55	71	37	64	69	49	58	62
Loss Drop 1 to E.H.L.	36	51	46	41	44	35	43	49	46	43	43
Loss E.H.L. to W.S.M.	13	23	24	28	35	18	19	21	20	16	22
Gross A.A. Canal Loss	107	150	149	124	150	90	126	139	115	117	127
Canal Loss & Regulation*	453	428	394	366	332	283	223	249	264	251	324
Total All IID Losses	560	578	543	490	482	373	349	388	379	368	451
Spill for System Regulation	88	86	78	70	67	36	27	28	26	20	53
Total for System Reg. & Canal Loss	648	664	621	560	549	409	376	416	405	388	504
Total Deliveries to Users**	2 250	2 396	2 415	2 446	2 513	2 399	2 312	2 470	2 365	2 476	2 404
System Efficiency - Percent	77.7	78.3	79.5	81.4	82.1	85.4	86.0	85.6	85.4	86.5	82.7 Use 83 %
Gross Area of Crops - Acres 1/	564	540	526	525	547	548	554	581	607	561	555
Net Acreage Irrigated - Acres 1/	440	434	436	430	430	432	432	437	445	441	436
Del. to Users-Ac.Ft./Ac. of Crop	3.99	4.44	4.59	4.66	4.59	4.38	4.17	4.25	3.90	4.41	4.33
Del. to Users- Ac.Ft./Ac. Irrigated	5.11	5.52	5.54	5.69	5.84	5.55	5.35	5.65	5.31	5.61	5.51
At Pilot Knob-Ac.Ft./Ac. Irrigated	6.59	7.05	6.96	6.99	7.12	6.50	6.22	6.60	6.22	6.49	6.67

*Canal loss and regulation includes seepage, transpiration & evaporation losses, unmeasured deliveries to some 1,500 or more service pipes, deliveries to farm homes, and farms less than 2 acres.

**Deliveries to users & canal loss & regulation have been corrected to allow for estimated 10% undermeasurement of deliveries for years 1959 through 1963.

1/ In 1,000 Acres

Eng. Sec.
4/18/69

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IMPERIAL IRRIGATION DISTRICT
WATER DISTRIBUTION
1959-1968
(1,000 A.F.)

Year	Received at Pilot Knob	Operational Loss			Canal Loss & Regulation*				Delivered To Users*
		Main Canals	Lateral Canals	Total	A.A.C.	Main Canals	Lateral Canals*	Total	
1959	2,898	30	58	88	107	245	208	560	2,250
1960	3,060	28	58	86	150	232	196	578	2,396
1961	3,036	24	54	78	149	206	188	543	2,415
1962	3,006	20	50	70	124	190	176	490	2,446
1963	3,062	19	48	67	150	186	146	482	2,513
1964	2,808	12	24	36	90	81	202	373	2,399
1965	2,688	11	16	27	126	67	156	349	2,312
1966	2,886	12	16	28	139	76	173	388	2,470
1967	2,770	13	13	26	115	87	177	379	2,365
1968	2,864	11	9	20	117	88	163	368	2,476
10 Year Average	2,908	18	35	53	127	146	178	451	2,404

*Canal loss and regulation and deliveries to users have been corrected to allow for estimated 10% undermeasurement of deliveries for years 1959 through 1963.

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